Whitehead & Associates
Environmental Consultants
197 Main Road Cardiff NSW 2285 Australia
Telephone +61 2 4954 4996 Facsimile +61 2 4954 4996
Email mail@whiteheadenvironmental.com.au

Stage 2

Wastewater Management Plan for Proposed Subdivision at Lot 2 DP 1120671 Alpine Drive, Tinonee NSW

Prepared for	RJS Strategies Pty Ltd
Prepared by	Nicholas Banbrook Whitehead & Associates Environmental Consultants Pty Ltd 197 Main Road CARDIFF NSW 2285
Telephone:	02 4954 4996
email:	nicholas@whiteheadenvironmental.com.au

Document Control Sheet

Document and Project Details	
Document Title:	Wastewater Management Plan for Proposed Subdivision at Lot 2 DP1120671 Alpine Drive, Tinonee NSW
Author:	Nicholas Banbrook
Project Manager:	Mark Saunders
Date of Issue:	12/07/19
Job Reference:	Stage 2 Report_01308_005
Synopsis:	This document presents the results of detailed field investigations and conceptual designs for sustainable on-site sewage management for a proposed subdivision at Lot 2 DP1120671 Alpine Drive, Tinonee.
Client Details	
Client:	RJS Strategies Pty Ltd
Primary Contact:	Tony Fish – PDA Planning

Document Distribution

Version Number	Date	Status	DISTRIBUTION – NUMBER OF COPIES (p – print copy; e – electronic copy)		
			Client	Other	Other
001	4/11/14	DRAFT FINAL	1e	-	-
002	7/11/14	FINAL	1e	-	-
003	22/9/15	FINAL R1	1e		
004	11/12/15	FINAL R2	1e	-	-
005	12/07/19	FINAL R3	1e	-	-

Document Verification

Checked by: Mark Saunders	***Issued by:*** Nicholas Banbrook

Disclaimer

The information contained in this report is based on independent research undertaken by Nicholas Banbrook of Whitehead & Associates Environmental Consultants Pty Ltd (W&A). To our knowledge, it does not contain any false, misleading or incomplete information. Recommendations are based on an appraisal of the site conditions subject to the limited scope and resources available for this project, and follow relevant industry standards. The work performed by W&A included a desktop review and limited soil sampling only, and the conclusions made in this report are based on the information gained and the assumptions as outlined. Under no circumstances, can it be considered that these results represent the actual state of the site at all points, as subsurface conditions are inherently variable. Concentrations of contaminants may also change with time, and the conclusions in this report have a limited lifespan.

Copyright Note

Table of Contents

Minimum Standard DAF ACCEPTANCE CRITERIA (High Hazard)		
Introduction and Background	Name, contact details and qualifications of author(s)	☒
	Site location and owner details	☒
	Allotment size	☒
	Proposed / existing water supply	☒
	Number of new building entitlements	☒
	Availability of sewer	☒
	OSSM hazard class confirmed by the designer/installer	☒
Site and Soil Assessment	Broad overview of locality and landscape characteristics (paragraph and locality map)	☒
	Detail of date, time and assessment methodology	☒
	Site and soil assessment that considers all parameters listed in Table 6.1 of the DAF in accordance with AS/NZS 1547:2012	☒
	Summary of available published soils information for the Site	☒
	Soil assessment that considers all parameters listed in 6.1 of the DAF in accordance with AS/NZS 1547:2012	☒
	Where multiple soil facets are present the site plan should show the approximate boundary between facets (≥3 test pits per soil facet)	☒
	Brief explanation of the implications of observed site and soil features for system design and performance and recommended design elements to overcome constraints	☒
	Recommendations on any soil amelioration and Site mitigation required	☒
System Selection	Summarise potential treatment and land application systems considered, including advantages and limitations	☒
	Brief statement justifying selection of treatment land application system	☒
	Sizing of land application system using the most limiting of monthly soil water and annual nutrient balances (see Technical Manual)	☒
Design	Site specific calculation of the design wastewater generation rates in accordance with AS/NZS 1547:2012	☒
	Accreditation details for the selected treatment system (attach certificate)	☒
	Nominated area monthly water balance calculations sized for zero overflow in the wettest month (table summarising inputs and assumptions accompanied by a summary table of results)	☒
Site Plan	Survey plan	☒
	Proposed allotment boundaries, dimensions and area	☒
	Location of buildings, swimming pools, paths, groundwater bores, dams and waterways	☒
	Location of exclusion zones (e.g. setback distances)	☒
	Location of primary and reserve EMAs	☒
	Two metre elevation contours	☒
	Location of drainage pipework (centreline)	☒

Cumulative Impact Assessment (where required)	Summary approach taken and confirmation of compliance with the minimum standards documented in Section 2.7	☒
	Methodology documenting the basis and source of input data including reference to site specific data, published information or the Technical Manual to justify use	☒
	Results demonstrating compliance with local water quality objectives and adequate management of health risk as defined and demonstrated in Section 10.1.1 of the Technical Manual	☒
	Brief discussion of long-term risks to health and environment and recommend management measures to address impacts	☒
Appendices	Soil bore logs for all test pits	☒
	Raw laboratory results for soil analysis	☒
	All design calculations and assumptions including screenshots of cumulative impact spreadsheets/models	☒

1 Introduction

Whitehead & Associates Environmental Consultants Pty Ltd ("W&A") were engaged by Tony Fish of PDA Planning on behalf of RJS Strategies Pty Ltd ("the Client") to prepare an on-site Wastewater Management Plan (WWMP) for a proposed 10-lot subdivision at Lot 2 DP1120671 Alpine Drive, Tinonee ("the Site"). Currently, there is no existing development at the Site, with the exception of proposed Lot 1 which contains a two (2) bedroom dwelling serviced by a secondary treatment system and (subsurface irrigation) land application area of ~300m^2.

This WWMP provides a detailed assessment of the conditions and constraints of the Site with regard to suitability for servicing the subdivision with On-site Sewage Management (OSSM), including a conceptual design to enable development approval from Greater Taree City Council ("Council"). The WWMP has been undertaken in reference to the assessment and design principles of:

- AS/NZS 1547:2012 *On-site Domestic Wastewater Management* (Standards Australia / Standards New Zealand, 2012);
- Environment & Health Protection Guidelines: *On-site Sewage Management for Single Households* (Department of Local Government, 1998);
- Greater Taree City Council (2012) *On-site Sewage Development Assessment Framework* (DAF);
- Greater Taree City Council (2012) *On-site Sewage Management Technical Manual*; and
- NSW Department of Environment and Conservation (2004), *Environmental Guidelines for the Use of Effluent by Irrigation*.

The Site OSSM hazard classification is identified as 'High Risk' under Greater Taree City Council's DAF (2012). This WWMP addresses the requirements of the DAF (2012) for increasing building entitlements. The tables presented summarise the Site constraints, which (where relevant) are discussed in terms of the degree of limitation they present for on-site wastewater treatment and effluent management. Reference is made to the rating scales described in Table 4 of DLG (1998) or, as appropriate, the discussion in Tables K1/K2 of AS/NZS 1547:2012.

2 Scope of Works

Following completion of our land capability assessment (Stage 1), we have confirmed Council's identification of the Site as a "high hazard" allotment for subdivision and determined the relevant key acceptance criteria and level of investigation required by the DAF. Subsequently, the project study methodology included, but was not limited to:

- Confirmation of the OSSM hazard classification of the Site;
- reviewing a range of background information relevant to the project, including the development/design plans and any other relevant information from previous studies in the area;
- visiting the site (once) to undertake detailed site investigations, including the excavation of at least one borehole on each of the proposed allotments (minimum of 2 per identified soil facet) to assess soil physical characteristics such as texture, structure, depth, colour, drainage and presence of watertables;
- undertaking in-house laboratory analysis of pH, electrical conductivity and Emerson Aggregate Class of the soil samples;

- Provision of soil samples for independent lab analysis of phosphorus sorption and cation exchange capacity (nutrient modelling) and exchangeable sodium percentage (soil dispersion potential). Our proposal allows for 3 composite samples representative of typical Site conditions;
- assessing a range of site constraints including landform, slope, aspect, drainage, flooding and proximity to sensitive environments;
- preparing a general assessment of the existing condition of the local receiving environment, in particular, sensitivity to OSSM impacts and determine the implications of these constraints for design of wastewater treatment and land application systems;
- estimating likely wastewater loads (quantity and quality) from the proposed development lot for dwelling sizes up to 5 bedrooms; and
- assessing overall site capability for on-site wastewater management and determining an appropriate level of wastewater treatment and the preferred method of land application of effluent to overcome the site constraints. These decisions will be made having regard to relevant standards and guidelines including *AS/NZS 1547:2012 On-Site Domestic Wastewater Management, Environment, and Health Protection Guidelines: On-Site Sewage Management for Single Households* (NSW DLG, 1998) and the *GTCC On-Site Sewage Development Assessment Framework* (2012).

System Sizing, Selection and Design

- identifying the suitable wastewater treatment and land application system options available and preparing preliminary design calculations for a minimum two (2) alternate options;
- providing justification for preferred system selection;
- undertaking detailed (monthly) soil water and nutrient (annual mass-balance) modelling to size a suitable land application area for the development and to demonstrate compliance with assessment criteria as set down in Section 1.3 of the DAF;
- identifying an appropriate location and configuration for the land application area on the Site and provide a concept design on a suitably scaled Site Plan (as provided to W&A);
- outlining any land improvement works or mitigation measures required to address particular constraints in the land application area (e.g. terracing, soil importation, vegetation improvement, landscaping, stormwater diversion); and
- preparing a detailed site plan including:
  - proposed boundaries, dimensions and area,
  - location of existing/proposed structures or improvements,
  - location of primary and reserve disposal areas, and
  - identification of setback areas or unsuitable ground conditions.

Cumulative Impacts

- preparing a standard CIA for the proposal in accordance with the requirements of the DAF (Section 2.7), including:
    - daily water and nutrient mass balance modelling on a site specific basis to derive average annual hydraulic and pollutant loads to surface and subsurface export routes for each nominated LAA system type.
    - average annual estimate of runoff volumes using a volumetric coefficient of rainfall.
    - application of a catchment attenuation factor to combined surface and subsurface on-site loads based on broad characteristics of the receiving environment
    - establishing background (ambient) pollutant loads/concentrations for the locality using prescribed reference sources.
    - mass balance modelling of combining attenuated on-site system flows and loads with catchment inputs.
    - results demonstrating compliance with the environment and health protection targets (DAF Table 2-14).

Reporting

- provision of this written Wastewater Management Report, including a Site Plan, describing the results and recommendations from our investigations and a brief discussion of long-term risks to health and environment and recommended management measures to address impacts.

3 Site Description

The Site is located at Lot 2 DP1120671 Alpine Drive, Tinonee. The Site is presently un-sewered and will be serviced by reticulated (town) water supply. The total area of the Site is approximately 17.5ha. Site access is via Alpine Drive. A detailed Site Plan showing the available Effluent Management Area (EMA) for each proposed lot is provided in Appendix A.

3.1 Hazard Classification

This Site has been identified by the GTCC DAF (2012) as a 'high hazard' allotment. A validation on the hazard class for the Site was conducted due to the broad scale of the initial hazard assessment. The confirmation procedure uses the same logic matrix as provided in Table 5.1 and 5.2 of the GTCC Technical Manual (2012) and is attached in Appendix D of this WWMP.

The overall OSSM hazard classification for the Site remains the same as identified by the GTCC DAF (2012); high (climate = high, slope and soil = medium).

Slope Hazard – Site slopes range between 2-15% within the available EMAs, presenting a **medium** hazard rating.

Soil Hazard – the soil hazard is separated into three (3) parameters; depth hazard, hydraulic hazard and pollution hazard. Site soils within the available EMAs had a moderate soil profile depth 1,000 – 2,000mm, with no groundwater encountered. This presents a medium depth hazard rating. Soils throughout the Site consist of imperfectly drained clay loam, which present a low hydraulic hazard rating. Finally, Site soils have low cation exchange capacity and sodicity potential, while phosphorus sorption capacity is considered to be moderate to high. This equates to a low pollution hazard rating. Applying the weighted average score for each parameter gives a value of 1.5, presenting an overall **low** soil hazard rating.

Climate Hazard – Climate data for the Site was obtained from Table 8-2 in the GTCC On-site Sewage Technical Manual (2012). The Site is located within the coastal climatic zone, with evapotranspiration providing legitimate output for applied effluent for 42% of the year. Mean annual climate data for the Site indicates that there are seven (7) months in the year that exhibit a soil moisture surplus. This presents a **high** climate hazard rating.

Proximity Hazard – the available EMAs on each proposed lot achieve the prescribed setbacks from intermittent (40m) surface watercourses. Sufficient separation (100m) is achievable from SEPP14 wetlands and the prescribed 100m setbacks from permanent watercourses are also achieved. This presents a **low** proximity hazard rating.

The Site is not located within 100m of SEPP14 wetlands or within 500m of SEPP 62 Aquaculture Zones and potable water supply catchments.

Flood Hazard – the point of effluent application and the treatment unit electrical components will be located above the 1% Annual Exceedance Probability (AEP) (1 in 100 year Annual Recurrence Interval (ARI)) flood level; presenting a **low** flood hazard rating.

4 Site & Soil Assessment

4.1 Site Physical Characteristics

A Site and Soil Assessment was undertaken on the 1st of August 2014 by Nicholas Banbrook of Whitehead & Associates. A description of the Site physical conditions and the degree of limitation they pose to on-site effluent management is provided in Table 1 below. Reference is made to the rating scale in NSW DLG (1998) and, where appropriate, the GTCC On-site Sewage Management Technical Manual (2012).

Table 1 Site Physical Conditions & Constraints

Parameter	Constraint
Climate: Climatic data for use in water balance calculations were obtained for the Site from Table 8-2 in the GTCC On-site Sewage Technical Manual (2012). The Site experiences a temperate climate, typical of south-eastern Australia. Potential evapotranspiration exceeds rainfall for the only 5 months of the year at the Site. The soil moisture deficit is expected to be most limiting during the autumn/winter period. This presents a moderate limitation to OSSM.	Moderate
Aspect and Exposure: Site aspects are predominantly north to easterly, with some minor areas located on south facing slopes. Good solar and wind exposure was observed within the proposed EMA locations. This presents a minor limitation to OSSM.	Minor
Vegetation: The Site is primarily vegetated by mixed pasture species, with small stands of trees lining incised drainage channels. A dry sclerophyll forested area was identified in the north-western portion of the Site, within proposed Lots 4, 5 and 6. At the time of inspection, healthy ground cover was observed within all proposed EMA locations with no indication of poor soil fertility. This presents a minor limitation to OSSM.	Minor
Landform and Slope: The Site exhibits slopes of up to 20%; ranging between 5% and 15% within the proposed LAA locations. This presents a minor to moderate limitation to OSSM.	Minor to Moderate
Rocks and Rock Outcrops: Bedrock or rock outcrops were not encountered at the Site, either through direct observation or during test pit excavations in the proposed EMA locations. This presents a minor limitation to OSSM.	Minor
Fill: Evidence of imported fill was not observed during the site and soil investigations. Natural soil profiles were observed in all excavated test pits. This presents a minor limitation to OSSM.	Minor

Parameter	Constraint
Erosion Potential: At present, the Site surface is generally stable with no erosion observed at the time of inspection. This presents a minor limitation to OSSM.	Minor
Groundwater and Site Drainage: A search of the NSW Office of Water's groundwater bores, maps and records indicated that there are no registered groundwater bores within 250m of the Site. Surface drainage is considered to be generally good throughout the Site. However, some subsoil mottling (>0.5m) was observed in some areas of the Site, indicating that periods of inhibited drainage occurs within subsoils. This presents a minor limitation for OSSM.	Minor
Flood Potential and Proximity to Surface Waters: There are several intermittent watercourses and no permanent surface watercourses located within the Site. The Site has been surveyed and 1m elevations contours are presented on the Site Plan in Figure 1. The minimum recorded elevation for the Site is 13m Australian Height Datum (AHD). Review of the Greater Taree Local Environmental Plan (2010) Flood Planning Map (Sheet – FLD_011) indicates that the Site is located outside the specified flood planning area; therefore, flooding is not expected to be a constraint for OSSM.	Minor
Available EMA: The key factors that determine positioning of the proposed Land Application Area (LAA) within each proposed lot include the constraints imposed by the extent of the proposed development, as well as buffer distance requirements to property boundaries and other sensitive receptors. Given the size of the proposed lots and provision of adequate buffer distances, the availability of EMA is not considered to be a significant constraint for OSSM. Table 2-5 of the GTCC DAF (2012) acceptance criteria checklist states that for high hazard subdivisions, all proposed lots must contain at least 4,000m^2 of useable land. In addition, all proposed EMA's must meet or exceed GTCC setback distances for watercourses, creeks and drains to account for cumulative impacts on sensitive receptors. Given that proposed Lots 2, 3, 8 and 9 cannot meet these conditions, a cumulative impact assessment (CIA) is required to be undertaken to confirm the sustainability of the proposal, in accordance with Section 2.4.4 of the DAF and Section 10.2 of the GTCC On-site Sewage Technical Manual.	Minor

4.2 Soil Landscape

Currently, there is no published soil landscape mapping series for this region. Regional soil profile information was accessed through the Soil and Land Information System (SALIS), which provides a substantial database of information collected by earth scientists and other practitioners.

The Soil Technical Report for the nearest SALIS soil profile '528' is located approximately 750m southeast of the Site. The report identifies the soil as a Bleached-Leptic Tenosol. This soil type is described as imperfectly drained, with low fertility and moderate erosion hazard. The described soil profile comprised dark brown sandy clay loam to 150mm depth; overlying a conspicuous bleached medium clay horizon, with an earthy fabric and 20 – 50% coarse gravel.

4.3 Soil Survey & Physical Characteristics

Site soils were observed and examined by excavating eight (8) test pits (TPs) using a hand auger. Soils were generally consistent across the Site with topsoils composed of clay loam material between 200 – 600mm depth, with moderate to weak structure and varying amounts of coarse material; overlying light clay subsoil. Horizon boundaries were generally well defined. Some mottling of light clay was observed in the lower portion of the soil profile in TP6. The descriptions generally conform to the available SALIS soil profile information with the exception of the medium clay subsoil horizon, which was not identified in any of the excavated test pits.

The soil survey had two principal aims – to verify regional soil landscape mapping information and to assess local soil conditions in areas considered suitable for land application of effluent. Table 2 summarises the key soil physical and chemical constraints. Appendix B provides soil borelog summaries for each test pit.

4.4 Soil Chemical Characteristics

Samples of discrete soil horizons were collected for subsequent laboratory analysis. Samples were taken from each horizon and were analysed in-house for pH, Electrical Conductivity (ECe) and Emerson Aggregate Class. Three composite soil samples were taken for independent laboratory analysis for exchangeable sodium (ESP), cation exchange (CEC) and phosphorus sorption capacity (P-sorp).

Table 2 provides a summary of the results and discussion of the soil chemistry with respect to soil constraints for on-site effluent management. Reference is made to the rating scale described in Table 6 of DLG (1998) and, where appropriate, the GTCC On-site Sewage Management Technical Manual (2012). Raw data and interpretation is presented in Appendix C.

Table 2 Soil Physical & Chemical Characteristics & Constraints

Parameter	Constraint
Soil Depth: Bedrock was not encountered in any of the TPs during the Site investigations. Soil depth in the vicinity of the available EMAs is >0.5m, with some restriction due to coarse fragments and hardpan at varying depths in the majority of the TPs. This presents a moderate limitation to OSSM.	Moderate
Depth to water table: The depth of the vadose zone (i.e. non-saturated soil material above water table) is >1.0m. Based on soil moisture and mottling characteristics, the depth to seasonal/permanent groundwater is estimated to be at >1.0m depth, which is beyond the zone of influence regarding OSSM, given the preferred land application method.	Minor
Coarse Fragments (%): Coarse fragments may impede plant growth by reducing soil water holding	Moderate

Parameter	Constraint
capacity, nutrient retention capacity and overall fertility because of the reduced fine earth fraction and increased permeability. Coarse fragments were observed in varying amounts between 2 – 25% within each of the excavated TPs, generally increasing with depth. Approximately 30% coarse fragments were observed throughout the depth of the soil profile in soil TP4. Based on the depth and concentration of coarse fragments within the soil profile, the limitation to OSSM is expected to be moderate.	
Soil Permeability and Design Loading Rates: Soil permeability was not directly measured but can be inferred from observed soil properties. AS/NZS 1547:2012 describes conservative Design Loading Rates (DLRs) for mound systems (Table N1) and Design Irrigation Rates (DIRs) for irrigation systems (Table M1), depending on two important soil properties – texture and structure. Soil depth, colour, mottling and drainage characteristics are also important to consider and guide selection of appropriate loading rates. Table M2 in AS/NZS 1547:2012 provides recommendations on reductions in DIR according to slope. Therefore, a 20% reduction in DIR is recommended for subsurface irrigation, based on site slopes ranging from 10 – 20%. Effluent management options for the Site are limited, given the permeability of the light clay subsoil horizon in TP6 occurring at >500mm depth, as well as refusal in the majority of the remaining TPs on coarse material and hardpan. Based on this, conservative soil loading rates have been adopted for the basis of land application system design. Soil augmentation is recommended to improve permeability and structure, as discussed in Section 8.3 of this report. Indicative permeability of the most limiting soil texture was used to select an appropriate soil loading rate. This soil type is classified as a well-structured Category 5 soil (light clay) and can be described as imperfectly drained, with an indicative permeability (K_{sat}) of 0.12 – 0.5m/day. Based upon slope, soil characteristics and (secondary) wastewater quality, the following conservative DLR/DIR is recommended for sizing the required LAA: • 8mm/day (mounds) • 3.0mm/day (subsurface irrigation on <10% slope) • 2.4mm/day (subsurface irrigation on 10 – 20% slope) Subsurface drip irrigation systems installed in Category 3 to 5 soils should be installed in an adequate depth of topsoil (in the order of 150 – 250mm) to slow the soakage and assist with nutrient reduction.	Moderate
pH: The pH of 1:5 soil/water suspensions were measured in-house using a *Hanna*™ hand held pH / EC meter. The measured pH of the soil samples (topsoils and subsoils) ranged from 5.1 to 5.9 respectively. Soils range from moderately acidic to strongly acidic; however, plant growth did not appear to be affected by soil acidity at the time of inspection. Soil pH presents a moderate limitation for OSSM at the Site and will be managed using soil improvement methods.	Moderate

Parameter	Constraint
Electrical Conductivity (EC_e): Electrical conductivity of the saturated extract (EC_e) was calculated by first measuring the electrical conductivity of 1:5 soil in water suspensions and using appropriate multiplier factors (based on soil texture) to convert the 1:5 suspension EC to EC_e. Soil samples were found to be non-saline, having EC_e values of 0.01 – 0.3 dS/m. Soil salinity is not considered to pose a significant constraint for OSSM.	Minor
Modified Emerson Aggregate Class: The Modified Emerson Aggregate Test (EAT) is a measure of soil dispersibility and susceptibility to erosion and structural degradation. It assesses the physical changes that occur in a single air-dried ped (naturally forming aggregate) of soil when immersed in water; specifically whether the soil slakes and falls apart or disperses and clouds the water. The test was performed on all samples collected, which yielded Emerson Aggregate Classes ranging from 2(2) – 6 in topsoils to 2(2) – 5 in subsoils. The EAT classifications indicate high levels of slaking with some dispersion within subsoil horizons. Given that the limiting EAT class of soils in the proposed EMA locations occur within surface soils, the associated dispersion risk will be mitigated through selection of an appropriately conservative hydraulic loading rate and soil augmentation prior to installation of the land application system. This presents a moderate constraint for OSSM.	Moderate
Sodicity (Exchangeable Sodium Percentage - ESP) (%): The Exchangeable Sodium Percentage (ESP) is the proportion of sodium on the cation exchange sites reported as percentage of exchangeable cations and is an important indicator of sodicity, which affects soil structural stability and susceptibility to dispersion. The ESP is a measure of how readily the soils allow sodium from wastewater to be substituted in the soil lattice for other cations. Once accepted, the weak sodium bonds allow increased structural degradation of the soil, increasing erosion risk. It is calculated as [% Na / CEC] x 100. Hazelton & Murphy (2007) suggest: • ESP values less than 6 are rated as non-sodic; • ESP values between 6 and 15 are rated as sodic; • ESP values between 15 and 25 are rated as strongly sodic; and • ESP values greater than 25 are rated as very strongly sodic. Three composite soil samples were analysed for ESP, giving the recorded values of 0.5 – 4.7, indicating that Site soils are non-sodic. This presents a minor limitation for OSSM.	Minor
Cation Exchange Capacity (cmol/kg): The Cation Exchange Capacity (CEC) is the capacity of the soil to hold and exchange cations [aluminium, calcium, magnesium, potassium and sodium]. It is a major controlling agent for soil structural stability, nutrient availability for plants	Minor to Moderate

Parameter	Constraint
and the soils' reaction to fertilisers and other ameliorants (Hazelton & Murphy, 2007). Like ESP, the CEC is a measure of how easily the soils accept excess cations from the wastewater. The CEC of the composite soil samples analysed were measured between 6.5 – 9.2cmol/kg. The CEC rating for the samples are considered low, indicating that plant growth may be inhibited by a lack of trace nutrients such as calcium, and the application of gypsum may be beneficial. The calcium/magnesium ratio of analysed samples was found to be good for two of the three samples analysed (2.2 and 2.8), with one sample found to be low (0.3). It is generally accepted that the Ca/Mg ratio should be near 2.0 to improve fertility and lower the risk of dispersion. This presents a minor to moderate limitation for OSSM and can be managed through pasture management practices. Further discussion on proposed mitigation measures is provided in Section 6.3.	
Phosphorus Sorption Capacity (kg/ha): The Phosphorus Sorption capacity (P-sorption) is used to calculate the potential immobilisation rate of phosphorus by the soil. The P-sorption capacity of a soil is an important feature that relates to the potential for a soil to bind any phosphorus that may not be utilised by the plants within an EMA. Phosphorus is required only to a limited extent by plants as a trace nutrient, but if there is an excess of phosphorus in environments where other limiting factors are not present (such as waterways), excess phosphorus can result in very high plant growth. Typically, on land, excess phosphorus is taken up by soil adsorption, or is flushed out of the soil into groundwater or surface water bodies. In many instances, P-sorption will be the dominant phosphorus removal mechanism when applying recycled water to the land. P-sorption analysis was undertaken on the three composite soil samples by Lanfax laboratories, Armidale. For the laboratory sample a five point isotherm of P-sorption capacity was generated. The methodology is described further in Patterson (2001). For the analysed soils, a nominal threshold P-sorption value (in mg/kg) is selected as the value that equates to roughly 70% of complete sorption or the point on the sorption curve where the predicted P-sorption value departs from the theoretical line. The soil profile's P-sorption capacity can be estimated by adding the contribution from each discrete horizon to achieve a total P-sorption capacity or (weighted average) for the available EMA. A bulk density of 1.5g/cm^3 was assumed and the relevant soil profile depth was used for the soil profile P-sorption calculation. Based upon this consideration, the design P-sorption capacity of the Site soils is estimated as 353mg/kg, which presents a minor limitation for OSSM.	Minor

4.5 Assessment of the Environmental Condition

Mid-Coast Water (MCW) provides potable water and municipal wastewater management services for the Manning, Great Lakes and Gloucester communities. MCW's annual State of the Environment (SOE) Report (2012/13) indicates the potable water supply extraction from the Manning River is a relatively small proportion of the total extractions from the river during low flow conditions (9% of the 95th percentile flow if these conditions persisted throughout the year). The Manning River is a relatively high yielding river with few stressors. The low flow extraction is regulated by a MCW water management plan.

The Site is located approximately 200m west of a small tributary that flows into the Manning River, approximately 1km to the east. The Manning River is the main potable water source for Taree and Wingham, with a total MCW extraction of 7,400ML in 2012/13. Treated municipal effluent is released to the Manning River and is regulated through NSW Environmental Protection Agency (EPA) licence limitations. The discharge volume in 2012/13 for each municipal wastewater treatment plant (WWTP) was found to be well below licence limits, with 12% of the total effluent reused or recycled for beneficial purposes. NSW Office of Water undertakes water monitoring on the Manning at four river gauging stations and four other sites on a monthly basis for faecal coliforms, total phosphorus, dissolved reactive phosphorus, total nitrogen, electrical conductivity, pH, temperature and turbidity. Effluent pollutant loads into the Manning River have shown a decline over the past 6 years. This can be partially attributed to improved effluent quality from WWTPs and increased effluent reuse within the catchment.

5 Wastewater Generation

5.1 Wastewater Quantity

The design (daily) hydraulic load for each proposed lot has been based on an assumed maximum five (5) bedroom dwelling and an estimated wastewater flow allowance of 150L/person/day in accordance with Table H1 in *AS/NZS1547:2012;* wastewater flow allowances for town water supply. To minimise wastewater generation from the proposed dwellings, it is recommended each dwelling be constructed in accordance with BASIX requirements, including installation of 'standard water reduction fittings'.

Standard water reduction fixtures for internal and external water use include:

- Taps – AAA rated;
- Toilets – 11/5.5 litre dual flush pan and cistern;
- Showers – 9L/minute; and
- Dishwashers (if used) – AAA rated using as little as 18 litres per wash.

From this, a conservative wastewater generation estimate for each proposed dwelling has been determined, based on the standard occupancy rate of 1.6 persons per bedroom, as specified in Council's DAF (2012). This equates to a design occupancy rate of 8 persons per dwelling.

Based on this, the design hydraulic load of **1,200L/day** (150L/day x 5 bedrooms x 1.6 persons per bedroom) has been adopted as the basis for the design of the treatment and effluent application systems on each proposed lot.

5.2 Wastewater Quality

The contaminants in domestic wastewater have the potential to create undesirable public health concerns and pollute waterways unless managed appropriately. As a result, domestic wastewater must be treated appropriately to remove the majority of pollutants to enable attenuation of the remaining pollutants through soil processes and plant uptake.

Wastewater generated by the proposed development is expected to be of a typical domestic household nature. As such, untreated wastewater is expected to have characteristics similar to that described in Table 3; which incorporates information taken from DLG (1998).

Table 3: Characteristics of Typical Untreated Domestic Wastewater

Parameter	Loading	Greywater %	Blackwater %
Daily Flow	150L/p/day	65	35
Biochemical Oxygen Demand	200-300mg/L	35	65
Suspended Solids	200-300mg/L	40	60
Total Nitrogen	20-100mg/L	20-40	60-80
Total Phosphorus	10-25mg/L	50-70	30-50
Faecal Coliforms	10^3 - 10^{10}cfu/100 mL	medium-high	high

(Source: DLG 1998 p.80)

5.2.1 Improving Wastewater Quality

As well as reducing water use, it is important that the wastewater stream is protected against harmful substances which could disrupt the biological treatment processes. The following is a list of general suggestions which could be implemented:

- Bleaches, disinfectants and other cleaning compounds can significantly impede biological wastewater treatment systems, because they kill bacteria and other micro-organisms that colonise the treatment system and help treat wastewater. These products should be used sparingly, and always checked to ensure that they are safe for biological wastewater treatment systems;
- Sodium adds to the total salinity of wastewater and can have detrimental impacts on soils when wastewater is disposed to the land. Sodium salts are present as fillers in many powder detergents. To reduce sodium levels in wastewater, liquid detergents are preferred;
- Phosphorus is an essential plant nutrient that can be applied to the land with no detrimental impacts, provided it is appropriately managed. However, it may cause pollution problems when it runs off and enters waterways. Phosphorus concentration in wastewater can be reduced by selecting detergents low in phosphorus;
- Organic matter, oils and fats can enter the waste stream from various sources. Excessive amounts of fats, oils and greases should not be disposed of into the wastewater stream; and
- Avoid placing oil, paint, petrol, strong acids or alkalis, degreasers, photography chemicals, cosmetics, lotions, pesticides, herbicides and antibiotics in the wastewater system. Even small amounts of these products can harm the performance of wastewater treatment systems. Such materials should not be disposed of down the drain and alternative disposal practices must be used.

6 Buffers

Buffer distances from LAAs are recommended to minimise risk to public health, maintain public amenity and protect sensitive environments. Buffer or setback distances are recommended to provide a form of mitigation against unidentified hazards and reduce potential pathways of human and environmental exposure.

W&A recommend the following environmental buffers, based on Table 6-8 GTCC DAF (2012);

- 250 metres from domestic groundwater bores;
- 100 metres from permanent watercourses;
- 40 metres from intermittent watercourses and dams;
- 6 metres if area up-gradient and 3 metres if area down-gradient of driveways, swimming pools and buildings; and
- 6 metres if area up-gradient and 3m if area down-gradient of property boundary.

Council response letter to the subdivision development application dated 3 July 2015 states that all proposed EMAs are required to be located outside of the identified utility easements within the Site. Based on this information, the subdivision layout has subsequently been revised to demonstrate compliant siting of all proposed EMAs, as shown in Figure 1 of Appendix A.

7 On-site Wastewater Management Strategy

7.1 Wastewater Treatment System Options

The Site is not serviced by a reticulated sewer system and provision of sewer to the area is unlikely in the near future. Further consideration of this option is therefore discarded.

Prior to selecting the preferred OSSM system(s) for each proposed lot, a number of options were considered. The preferred system(s) will best meet the required criteria of:

- acceptability to the Client and the facility users;
- protecting human health and the health of domestic animals;
- protecting the environment, including native flora and fauna, surface water and ground waters;
- providing beneficial reuse of wastewater;
- practicality of construction and maintenance; and
- economic viability.

A description of the main alternatives and their limitations are presented below.

7.1.1 Pump out Systems

This option involves the collection, primary treatment and storage of wastewater along with a regular (normally weekly) pump out of the accumulated waste materials. These wastes are removed by a pump out contractor and conveyed to a centralised sewerage treatment plant. Pump out is useful on sites that are unsuited to on-site wastewater management, due to (i) limited available area for land application or (ii) unsuitable soil or other site conditions.

On most sites pump out is undesirable due to the high ongoing cost. Pump out is not supported by Council as a long-term solution for OSSM. Failure, through poor design, neglect, or intentional discharge, presents a high risk to human health and the environment. Pump out does not allow beneficial reuse of wastewater and the option is discarded.

7.1.2 Primary Treatment (Septic) Systems

A conventional method for managing wastewater is the use of a septic tank with an associated soil absorption system. The septic tank provides primary treatment of wastewater, allowing solids and sludge to settle while oils and fats float to the top and form a scum layer. Routinely, sludge and scum is removed by a pump out contractor. Absorption trenches, pits and evapotranspiration beds have traditionally been used to dispose this effluent.

Primary treatment (septic) systems are generally low maintenance and less expensive to install and maintain, but should be sized correctly and purpose designed for the situation. They produce a low quality (primary) effluent that is relatively high in oxygen-consuming substances, nutrients and pathogens. Inappropriately sized or located soil absorption systems are prone to failure, due to formation of a clogging, biological "mat" that reduces absorption. Failure can cause environmental pollution and potential human health concerns. Because of unsuitable soil conditions and (relatively) shallow groundwater at the Site, further consideration of this option is discarded. Further, septic systems provide no opportunity for beneficial reuse of wastewater.

7.1.3 Secondary Treatment Systems

Secondary treatment is aimed at the removal of dissolved and suspended organic material by a combination of sedimentation and biological methods, usually incorporating both aerobic and anaerobic phases. Secondary treatment presents a significantly lower risk to human health and the environment, when compared to conventional primary (septic tank) systems. Conventional secondary treatment systems produce a high quality, secondary treated and disinfected effluent that is suitable for surface or subsurface irrigation reuse. Table 6-3 of the GTCC DAF describes minimum (acceptable) effluent quality performance standards for secondary treatment systems. These effluent quality standards are reproduced in Table 4.

Appropriate secondary treatment technologies include (but are not limited to) the following:

- Aerated Wastewater Treatment Systems (AWTS)
- Media filter systems
- Recirculating sand filters (site-specific design required)
- Reed beds (site-specific design required)

Advice on suitable systems can be sought from W&A prior to system selection and submission of the Section 68 application required by Council. A detailed list of NSW Health accredited systems can be found at:

http://www.health.nsw.gov.au/environment/domesticwastewater/Pages/default.aspx.

Disinfection units are typically installed as a standard component of proprietary secondary treatment systems, or can be installed as an add-on by the system supplier. We recommend that a disinfection system is installed with each chosen system. Domestic systems typically use one or a combination of the following disinfection methods:

- Ultra Violet (UV) irradiation
- Chlorination
- Ozone

Aerated Wastewater Treatment System (AWTS)

Domestic AWTS are pre-fabricated, mechanically aerated wastewater treatment systems designed to treat domestic (<1,500 L/day) wastewater flows. They are tank based systems, comprising either one or two separate tanks that typically employ the following processes:

- settling of solids and flotation of scum in an anaerobic primary chamber. This stage is omitted in some models and existing septic tanks could be used for this purpose as discussed previously.
- oxidation and consumption of organic matter through aerobic biological processes using (active or passive) mechanical aeration.
- clarification – secondary settling of solids.
- disinfection – usually by chlorination, or occasionally using ultraviolet irradiation.
- regular removal of sludge to maintain the process.

Media Filter Systems

Media filters provide secondary treatment for effluent that has already undergone primary treatment in a septic tank or similar device. They contain textile media configured to provide a very large surface area to volume ratio which hosts aerobic microorganisms that treat the effluent as it passes over the media, usually by gravity. Proprietary media filter systems typically incorporate the primary treatment tank into a stand-alone unit and recirculate a proportion of the treated effluent through the textile to improve effluent quality. The system is typically located below or at ground level.

Media filters are proven to be an effective and reliable secondary treatment device, consistently capable of achieving BOD <10mg/L and TSS <10mg/L and often better. The high density of the media filter material enables high loading rates and therefore a relatively small footprint; a filter unit (not including primary tank) of approximately 1.2m x 1m x 0.8m is usually adequate for a typical home. These systems are typically more capable of overcoming a lot of the constraints of AWTS listed above, and have significantly lower operating costs and better performance.

7.1.4 Recommended Wastewater Treatment System Alternatives

W&A have considered two (2) alternative treatment system scenarios for the proposed development lots. Both are capable of achieving the required selection criteria, but differ in how they address the issue of effluent reuse.

Scenario one comprises secondary treatment with disinfection and land application of the effluent via subsurface irrigation. Alternatively, scenario two comprises primary treatment within a (≥4,000L) septic tank, followed by pressure dosing of effluent (from a suitably sized pump well) to a Wisconsin Sand Mound. The Wisconsin Sand Mound land application method is designed to provide secondary treatment of effluent prior to reaching the natural ground surface, and is suitable for Sites with shallow soils.

Any of the secondary treatment systems described in this report is considered appropriate for each of the proposed lots. Selection of system type and brand is at the discretion of lot owners and will be detailed in applications to install and operate wastewater systems lodged with Council, following approval of the proposed subdivision. We recommend that lot owners consult the NSW Health website to become familiar with the range of accredited secondary systems currently available.

Additionally, where considered acceptable by Council, an appropriately sized septic tank (with outlet filter) may also be suitable to pre-treat effluent before disposal to an effluent reuse (Wisconsin) mound.

An important consideration when selecting a treatment system is matching the system size to the expected flows and type of occupancy (permanent/vacation). System selection should be carried out with this in mind prior to the allocation of building envelopes or construction of any dwelling on each lot. The exact positioning of treatment systems on site will depend on local gradient and level controls to allow gravity feed to the treatment systems from fixtures within the future site buildings and can be determined by the installer prior to obtaining consent for installation of the system. The positioning of a system should be done in consultation with a licensed plumber and Council.

7.2 Treated Effluent Quality

The expected effluent quality of all NSW Health accredited OSSM systems are provided in the associated accreditation certificates. Secondary treatment systems are expected to achieve the following minimum effluent quality standards, shown in Table 4.

Table 4: Characteristics of Secondary Treated Domestic Effluent

Parameter	Loading
Biochemical Oxygen Demand	<20mg/L
Suspended Solids	<30mg/L
Faecal Coliforms	<30cfu/100 mL
Total Nitrogen	30mg/L
Total Phosphorus	10mg/L

Successful performance of the wastewater treatment system relies on periodic monitoring and maintenance, which will be the responsibility of the owner. The aforementioned nutrient concentration targets for treated effluent have been adopted for nutrient balance modelling, based on published system testing data and independent advice.

7.3 Operation, Monitoring and Maintenance

All systems must be serviced by a suitably qualified technician at the prescribed intervals, in accordance with the NSW Health accreditation and the owner/operator manual for each system type.

Successful performance of the wastewater management system relies on good operational practice, as well as periodic monitoring and maintenance of the system. Certain aspects of monitoring and maintenance will be the responsibility of property owners, while other matters will be addressed through routine servicing by a suitably qualified technician, as required with most accredited wastewater treatment systems.

The subsurface irrigation system (if selected) must also be maintained in accordance with the manufacturer's recommendations. Mound maintenance requirements should be discussed with the installer during the selection process.

7.4 Effluent Management System

This section describes the Site capability for effluent management and provides design details, including sizing and positioning, for the recommended Land Application Area (LAA) on each proposed lot. The size and design of the LAAs has been determined using both water and nutrient balances and other related models and guidelines, as explained in the relevant sections.

In addition, we have undertaken daily time-step hydraulic and nutrient modelling using the 'Decentralised Sewage Model' (DSM) for the development in order to assess both the individual and cumulative impacts of multiple effluent management systems in the subdivision. These calculations are detailed further in Section 8 and model outputs are provided in Appendix F.

7.5 Land Application Options

Various land application options were considered including irrigation (surface and subsurface), effluent reuse mounds, evapotranspiration/absorption (ETA) beds and primary absorption trenches.

Conventional septic tanks with below-ground soil absorption trenches are considered undesirable given the presence of localised shallow subsoils with restricted vertical drainage occurring within the likely basal areas of the trenches and also very large trench lengths would be required using contemporary sizing methodologies which are impractical to service. ETA beds are considered unsuitable for similar reasons. Additionally, these subsurface disposal systems offer limited opportunity for effective reuse of effluent and do not represent current best practice.

Effluent irrigation systems are by far the most popular management option for on-site systems installed in recent years. Properly designed irrigation systems apply effluent at much lower volumetric rates and over larger areas than absorption trenches and beds. Effluent is applied at a rate that more closely matches plant evapotranspiration requirements leading to more effective effluent reuse. The reliance on soil absorption is relatively low and hence the risk of contaminants accumulating in the soil or leaching to groundwater is also low.

Over the last decade, surface spray irrigation has been the favoured method of managing secondary treated effluent on single residential allotments; however, due to concerns over the potential for human contact with effluent and also the poor management practices that have been associated with "moveable" type spray lines, it is being used less commonly in new installations.

7.6 Suitability of Land Application Options for Each Lot

Table 5 describes the suitability of effluent reuse options for each proposed lot, based on assessment of the existing constraints and allowing for modest land improvement works. Where more than one option is deemed suitable on any lot it is expected that future owners would be given the opportunity to select the option that best meets their landscaping and other objectives for the land.

Recommendations are based on our assessment of what could reasonably be established and maintained on each lot, within the limited scope of our investigations. We would recommend that a further detailed assessment be undertaken to accompany each future building application that will establish the precise positioning and additional design details for the selected land application option.

Table 5: Suitability of Land Application Options for each proposed Lot

Lot No.	Usable Area (Available EMA m^2)	Option 1 - Subsurface Irrigation	Option 2 - Wisconsin Sand Mound
2	2,500	✓	×
3	1,400	✓	✓
4	12,000	✓	✓
5	15,000	✓	✓
6	14,000	✓	✓
7	12,500	✓	✓

Lot No.	Usable Area (Available EMA m²)	Option 1 - Subsurface Irrigation	Option 2 - Wisconsin Sand Mound
8	3,200	✓	✓
9	900	✓	✓
10	8,000	✓	✓

Key to Table

✓ Suitable – the option is considered suitable based on the current site and soil conditions, and could be accommodated on the site with only modest (if any) land improvement works.

× Not suitable – the option is not considered suitable, based on the relatively broad scope and nature of these investigations.

All of the recommended LAA locations for each lot contain acceptable topsoil depths. Any recommended soil amelioration works should be conducted prior to installation of the proposed land application system.

The preferred land application method for all proposed lots within the development is subsurface irrigation. However, Wisconsin Sand Mounds are considered an appropriate alternate land application option for all proposed Lots, with the exception of proposed Lot 2 due to exceedance of the maximum allowable slope of 15% for sustainable mound design within the available EMA.

It is not our intention to rule out other options if, during subsequent detailed investigations, it can be shown that these will meet the performance objectives and requirements expected by Council. Therefore, options that are recorded as not suitable above, could be further investigated once the positioning of buildings and other development works are known.

7.7 Location of the Preferred LAAs

The preferred location of the LAA for each proposed lot is in a mid-slope position of 5-20% slope, with good exposure to sun and wind, and meets the aforementioned buffer requirements, as indicated on the Site Plan (Figure 1, Appendix A). On all proposed lots the LAA has been positioned on the lowest gradient area of the lot, away from the anticipated building envelope. The minimum available EMA is approximately 900m^2 and is located on proposed Lot 9.

7.8 (LAA Option 1) Subsurface Irrigation

The preferred type of irrigation for the development is pressure-compensating, subsurface drip irrigation. Subsurface irrigation (SSI) is suitable within lawn and landscaped areas and applies effluent within the root-zone of plants for optimum irrigation efficiency. It is an ideal option for ensuring even, widespread coverage of the proposed irrigation area. Subsurface irrigation installation does not require any bulk materials or heavy machinery and irrigation lines can be simply installed with a small trench digger or “ditch-witch”.

Proprietary, pressure-compensating drip irrigation pipe designed for use with treated effluent should be used that will ensure distribution of effluent at uniform, controlled application rates. These products have been specifically designed for use with effluent and allow for the higher BOD_5, suspended solids, nutrient and biological loads usually present in effluent compared to potable water. They contain specially designed emitters that reduce the risk of blockage, typically incorporating chemicals that provide protection against root intrusion and biofilm development (e.g. Trifluralin). The dripper lines are coloured lilac to clearly identify that they are irrigating treated effluent.

Lateral pipes should be spaced to provide good and even coverage of the area they service. Generally they should be no more than 0.6m apart, roughly parallel and along the contour as close as possible.

An in-line 120µm disc filter may be installed to minimise the amount of solids entering the pipelines and emitters. This must be removed and cleaned regularly (at least at 3-monthly intervals). Alternately, a flush main may be installed to periodically clean-out the irrigation lines to provide effective long term performance. Either manual or automatic flush valves may be installed, with flush water directed back to the treatment system. Air release valves will be installed at the high points in individual irrigation areas to prevent soil particles being sucked into the lines at the end of pump cycles as pipelines depressurise.

Figure 2 provides a schematic representation of a generic subsurface irrigation system, courtesy of Netafim Australia. Specialist advice must be obtained for designing and installing the irrigation system.

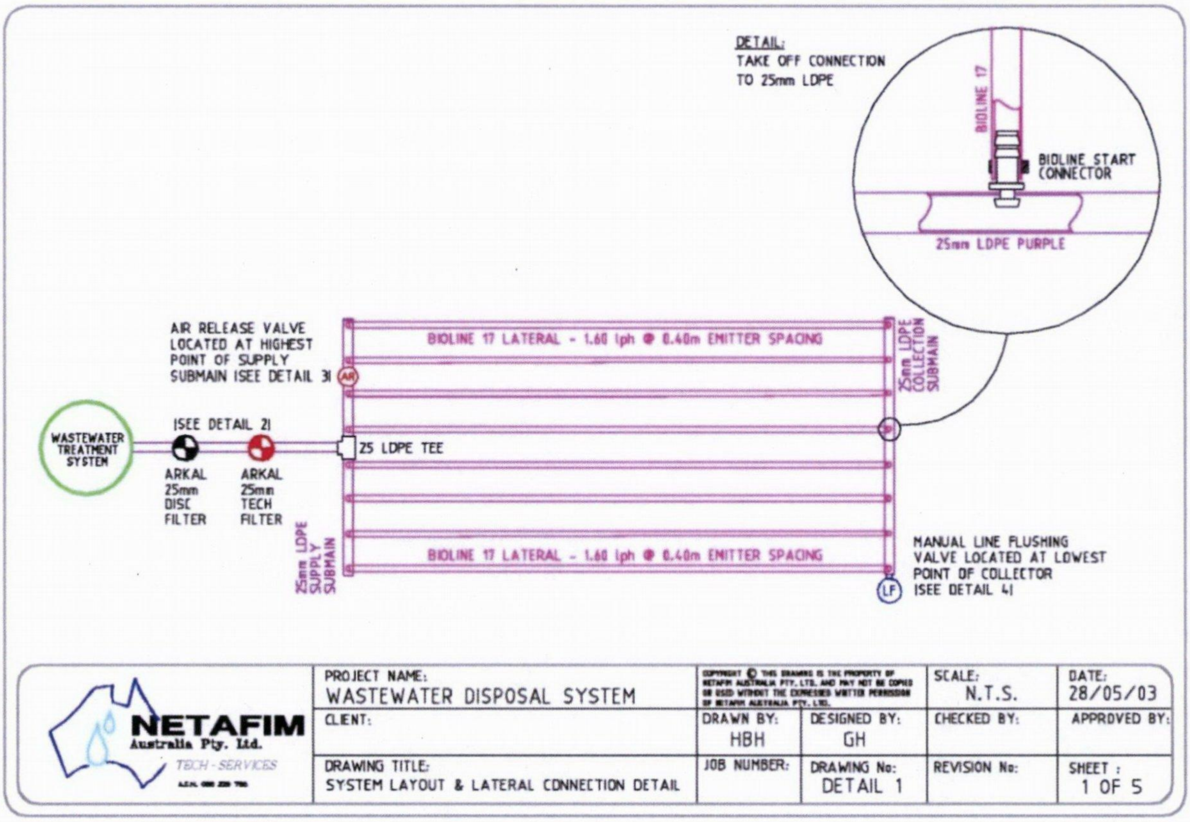


Figure 2: Typical Subsurface Irrigation Detail (courtesy of Netafim Australia).

7.8.1 Irrigation Area Sizing (Water and Nutrient Balance)

Preliminary water and nutrient balance modelling was undertaken to determine sustainable application rates for the proposed lots and to estimate the necessary size of the LAA required to manage the proposed hydraulic and nutrient load from the proposed development. The procedures for this generally follow the DLG (1998) guidelines. Appendix D contains the modelling outputs for each scenario.

The water balance used is a monthly model adapted from the "Nominated Area Method" described in DLG (1998). These calculations determined minimum LAA size for the given effluent load for each month of the year. The water balance can be expressed by the following equation:

Precipitation + Effluent Applied = Evapotranspiration + Percolation + Storage

Irrigation areas are calculated to achieve no net excess (overflow) of water and hence zero storage for all months. The water balance conservatively assumes a retained rainfall coefficient of 0.8; that is, an estimated 80% of rainfall will percolate into the soil within the LAA and 20% will run off. Given the moderate slopes and good groundcover at the Site, this is considered a conservative value. The rainfall hydraulic load is incorporated into the water balance to ensure that runoff from the LAAs will not occur under typical (design) climate conditions.

A conservative nutrient balance was also undertaken, which calculates the minimum irrigation area requirements to enable nutrients to be assimilated by the soils and vegetation. The nutrient balance used here is based on the simplistic DLG (1998) methodology, but improves this by more accurately accounting for natural nutrient cycles and processes. It acknowledges that a proportion of nitrogen will be retained in the soil through processes such as ammonification (the conversion of organic nitrogen to ammonia) and a certain amount will be lost by denitrification, microbial digestion and volatilisation (Patterson, 2003). Patterson (2002) estimates that these processes may account for up to 40% of total nitrogen lost from soil. In this case, a more conservative estimate of 20% is adopted for the nitrogen losses due to soil processes.

The water and nutrient balances were modelled using the design daily hydraulic load of 1,200L/day. Table 6 below contains the input data and results of the water and nutrient balance modelling.

Table 6: Inputs for and Results of Water and Nutrient Balance Modelling

Parameter	Units	Value	Comments
Effluent Load	L/day	1,200	150L x 5bdr x 1.6p/bdr.
Precipitation	mm/month	Taree - Mean Monthly	Table 8-2 in the GTCC On-site Sewage Technical Manual (2012).
Pan Evaporation	mm/month	Taree - Mean Monthly	Table 8-2 in the GTCC On-site Sewage Technical Manual (2012).
Runoff Coefficient	unit less	0.8	Proportion of rainfall that remains onsite and infiltrates the soil, allowing for runoff.
Crop Factor	unit less	0.55 – 0.85	Table 8-2 in the GTCC On-site Sewage Technical Manual (2012).
Design Irrigation Rate (DIR)	mm/day	3.0	Based on soil texture class.
Effluent total nitrogen concentration	mg/L	30	Expected value based on domestic WQ from a STS.
Effluent total phosphorus concentration	mg/L	10	Expected value based on domestic WQ from a STS.

Nitrogen conversion rate (soil processes)	annual percentage	20	Conservative estimate of in-soil conversion processes.
Nitrogen plant uptake	kg/Ha/yr	260	Roughly half that expected of effluent irrigated pasture (NSW DECCW, 2004).
Phosphorus plant uptake	kg/Ha/yr	30	Roughly half that expected of effluent irrigated pasture (NSW DECCW, 2004).
Soil phosphorus sorption capacity	mg/kg	353	Based on laboratory analysis.
Design system life	years	50	Reasonable service life for system.
Minimum irrigation area for total nitrogen load, without off-site export	m^2	404	
Minimum irrigation area for total phosphorus load, without off-site export	m^2	709	
Minimum irrigation area for total hydraulic load, without off-site export	m^2	**780**	LAA slope <10%
	m^2	**1,280**	LAA slope 10 - 20%

Based on the modelling outcomes presented in Appendix D, the hydraulic load is the limiting factor for sizing the required LAA on each proposed lot. The required irrigation area allows for zero wet weather storage. The monthly balance shows that with zero storage, the minimum irrigation area required for lots with slopes <10% is 780m^2 (rounded to the nearest 10m^2). The minimum irrigation area required for lots with slopes between 10 – 20% is 1,280m^2, based on a 20% DIR reduction (AS/NZS 1547:2012) to account for downslope seepage.

As such, proposed Lots 2, 3 and 10 require 1,280m^2 of irrigation area to assimilate the anticipated daily hydraulic load, with the remaining lots (4, 5, 6, 7, 8 and 9) requiring the lesser LAA of 780m^2.

7.8.2 Detailed Irrigation System Design and Management

A detailed land application system design is beyond the scope of this report; however, this should be prepared upon receipt of development approval and before installation of the system(s). The detailed design should be undertaken by an irrigation specialist experienced with wastewater applications. The design should include consideration of the following matters:

- the irrigation plan must ensure that effluent is applied evenly across the approved LAA;
- a complete plan and specification should be prepared for all new irrigation areas and equipment. This will include details on the type, capacity, operation and maintenance of all irrigation equipment, the irrigation pump/s, distribution pipework, cleaning/flushing valves, irrigation controller/s, filters and distribution valves;

- procedures for irrigation scheduling should be discussed, including information on timing and duration of irrigation, permissible daily application rates, monitoring of Site and soil conditions (including soil moisture sensors, if required) to ensure that effluent is not irrigated when soils are saturated, recording of irrigation rates, maintaining water and nutrient budgets, vegetation pruning or harvesting regimes;
- any mitigation measures required to overcome specific Site constraints such as localised stormwater run-on or runoff problems should be incorporated into the irrigation design;
- regular inspection of the irrigation area should be undertaken to ensure that the system is serviceable, is effectively distributing the effluent and is not resulting in overloading and soil saturation over all or part of the irrigation area;
- the irrigation lines should be flushed regularly following the installer's recommendations;
- all in-line filters (if fitted) must be removed and cleaned regularly following the installer's recommendations;
- vegetation within the irrigation area should be regularly cut or pruned and removed from the area to maintain nutrient budgets;
- the irrigation area should be fenced, or otherwise managed to ensure that vehicles do not enter the area as this poses a risk of damaging irrigation equipment and compacting soils, to the detriment of the system;
- effluent should not be irrigated when the soil is saturated, in order to prevent surface runoff of effluent as well as excessive deep drainage in saturated soils; and
- no structures should be built or placed within the identified irrigation area.

7.9 (LAA Option 2) Wisconsin Sand Mounds

Land application of primary treated effluent via Wisconsin Sand Mound is also considered appropriate for the proposed development. Wisconsin Sand Mounds are raised beds of selected filter media (graded sand), which are constructed above the existing ground surface. Mounds allow treated wastewater to be sustainably applied at relatively higher rates than by irrigation and provide both evaporation and bed storage and allow for further treatment and nutrient assimilation. They have the benefit of reducing the total land area required for effluent application, but require a permanent dedicated space with a nutrient buffer area (which can be landscaped).

While Wisconsin Sand Mounds are considered to be a suitable alternate land application option, the overall cost to install would likely exceed that of SSI, rendering the option less desirable.

7.9.1 Mound Sizing

A Wisconsin Sand Mound has been sized to overcome the soil texture (permeability) and separation constraints within the available EMA. A proprietary design model was used to calculate the mound dimensions, based on the input data described below. The model conforms to the design recommendations outlined in AS/NZS 1547:2012, with minor modifications based on our experience with this type of land application system.

Based on our design, a five (5) bedroom domestic dwelling would require a mound basal area of approximately 270m^2. The smaller footprint of the mound, compared to the required area for irrigation, will provide more space for other future development on the lots.

Appendix D contains a copy of the modelling spreadsheets. Table 7 summarises the approximate dimensions of the mound(s).

The Wisconsin Sand Mound design does not take into consideration nutrient assimilation requirements; therefore, final sizing relies on the outputs of the annual nutrient balance previously described (Section 7.6.1). Based on this, a nutrient buffer of no less than 440m^2 (709m^2 – 270m^2) would be required to be maintained below (down slope) of the mound to allow for the uptake of excess nutrient within the available EMA. This area may be landscaped using appropriate shrub or groundcover species.

Table 7: Mound Sizing

Hydraulic Load (L/day)	Gravel Bed Dimensions (m)			Overall Mound Dimensions (m)		
	Length	Width	Thickness	Length	Width	Total Height
1,200	23.0	1.4	0.25	27.9	9.6	1.2

Wisconsin Sand Mound design requires detailed consideration of both Site and Mound specific parameters. Those relevant are discussed further here.

Slope of existing ground surface

The indicated Wisconsin Sand Mound dimensions are based on ≤15% slope, which is the maximum practical slope before the risk of downslope toe seepage becomes a significant limitation (see Table K1, AS/NZS 1547:2012). The preferred locations of the Wisconsin Sand Mounds, where considered suitable, are shown in Figure 1 of Appendix A.

Soil depth to limiting layer

The depth to the limiting layer was identified by soil survey and is approximately 0.5m below the ground surface.

Sand media loading rate (SLR)

The SLR relates to the loading rate at the gravel bed/sand interface. An upper limit of 50mm/day is recommended for primary treated effluent (AS/NZS 1547:2012).

Basal (soil) loading rate (BLR)

This value is the design loading rate at the sand/natural soil interface, or across the basal area. The BLR depends on soil texture, structure, depth to limiting layer and profile drainage characteristics. AS/NZS 1547:2012 provides suggested loading rates. In this case the existing moderately-structured clay loam topsoils will be retained and a conservative BLR of 8mm/day is recommended.

Linear loading rate (LLR)

The LLR relates to the volume of effluent applied per linear metre of effluent absorption system (measured along the slope) per day. If the movement through the soil is predominantly vertical then the linear loading rate is not limiting to design (a rate of 120-150L/m/d can be used). If the movement is predominantly horizontal (e.g. on steep slopes with heavy soils or shallow hardpans) then a much lower LLR of between 45-60L/m/d is recommended. The light clay subsoil and shallow hardpan are the limiting factors governing the mound dimensions.

The LLR determines the length of the gravel distribution bed relative to the width. If a relatively long, narrow mound design is preferred, then low LLR values are used in the design. An acceptable LLR for the mound design is 54L/m/day as the clay subsoils are considered limiting.

Batter Slope

For ease of maintenance, batter slopes should normally be around 3(horizontal):1(vertical). Steeper batters may be considered as long as appropriate landscaping is undertaken and the area can be properly maintained. Under no circumstances should the batter angle exceed 2:1. A batter slope of 3:1 has been selected for the proposed mound design to limit the overall height of the mound and minimise visual impact.

7.9.2 Construction and Positioning of Wisconsin Mound

The design provided is based largely on information sourced from the USA particularly that contained in Converse & Tyler (2000). However, in recognition of the merits of sand mound systems AS/NZS 1547:2012 includes information on selection, design and construction of sand mounds that is generally consistent with that published by Converse & Tyler. Additional design and construction information can be found in Appendix N of AS/NZS 1547:2012.

Before construction the existing ground surface is prepared by scarification, ploughing or deep ripping. This is vital to improve moisture infiltration to the subsoils and reduce the risk of lateral moisture flows, particularly where the natural soils are heavy-textured. Approximately 400mm of sand, with specific grain size and other characteristics, provides the basal layer. Above this sits a gravel distribution bed containing a pressurised effluent distribution system. The gravel bed is covered by a geofabric filter cloth and then a further layer of select sand is provided, ensuring that at least 200mm of material covers the gravel bed at the edges. The mound is finished with good quality topsoil (approximately 100mm thick) and a turf cover.

Mounds must be aligned as close as possible to the contour, to ensure that the base of the distribution bed is level. This configuration is also desirable as it maximises the across slope width for absorption, reducing the linear loading rate. We recommend that a buffer of not less than 3m be maintained between the mound and property boundaries, and 6m from driveways and paths.

7.9.3 Selection of Media Fill

Selection of a suitable sand fill media is critical to ensure effective operation of the effluent reuse mound. If the media contains too much fine material hydraulic conductivity will be reduced, increasing the risk of clogging and failure. Equally, too coarse a media will reduce hydraulic retention time, water holding capacity and treatment performance.

Washed, medium sand free of fines is desirable. It should meet the following criteria:

- free of clay, limestone or organic matter;
- <20% of particles greater than 2mm;
- <5% of particles smaller than 0.053mm; and
- Effective diameter D10 = 0.15 - 0.30, with a uniformity coefficient D60/D10 = 4 - 6.

Finding a local supplier of suitable material may not always be possible and it is suggested that the installer begin sourcing the sand material as early as possible. W&A can provide advice on sourcing suitable material if required.

7.9.4 Pump System and Distribution Network

To operate effectively, the Wisconsin Mound must be intermittently pressure dosed. A suitable pump and electronic controls will be required to manage the delivery of effluent to the mound. Timed, pressure dosing will ensure optimum distribution for maximum performance and will minimise the risk of hydraulic overloading and failure.

Because of the (design) mound size, the pressurised effluent distribution system should be divided into several zones that are dosed independently. The number of zones depends on the hydraulic design of the system, including pump capacity and diameter of delivery and distribution pipes. These details will be determined by the installer following approval of the concept design of the mound system by Council and prior to mound construction.

A suitable distribution network will comprise several runs (laterals) of durable, pressure-rated PVC line, connected to a common manifold. Such systems must be carefully designed to ensure even distribution. Further detailed design of the distribution network should be undertaken by a suitably qualified and experienced professional.

Observation tubes should be installed into the mound, extending from the surface down to the base of the mound. These are an extremely important component for trouble-shooting in case of hydraulic failure of the mound. 100mm PVC pipe is suitable, with the bottom section slotted to allow moisture to pass into and out of the tube. The tube must be firmly anchored within the mound to prevent inadvertent removal or damage.

7.9.5 Mound Finishing

Turf shall be laid on the mound immediately after completion. This is important for stabilisation and will also facilitate good evapotranspiration and nutrient uptake once the mound is in operation. Deep rooting plants must not be planted on the mound as their roots can interfere with the effluent distribution system and cause blockage. However, judicious planting of moisture-loving groundcover and shrubs is recommended around the outsides and particularly around the down slope area of the mound. This will assist the uptake of any seepage in wet weather. Selection of plants must be such that the mound area is not shaded, once fully grown. It is important that the mound receives good exposure to sun and wind to maximise evapotranspiration.

8 Cumulative Impact Assessment

8.1 Overview

The GTCC DAF (2012) and the GTCC On-site Sewage Management Technical Manual (2012) describe the requirements and procedures for standard and detailed Cumulative Impact Assessment (CIA).

Based on the confirmed hazard classification for the Site, the DAF requires a standard CIA to be undertaken for subdivision development on High hazard allotments where minimum usable area requirements are achieved (GTCC DAF, Table 2-13). The following sections describe the methodologies, minimum performance requirements and results of the standard CIA. A copy of the calculations and model outputs are provided in Appendix F.

8.2 Summary of Methodologies

The minimum standards for standard CIA procedures are set out in Table 2.14 of the GTCC DAF (2012) and GTCC OSSM Technical Manual (2012). The methodologies used to address each of the five risk assessment components therein are summarised in Table 8 (below).

Table 8: Minimum Requirements for a Standard Cumulative Impact Assessment

Risk Assessment Component	Minimum Standard Required	Methodological Approach
On-Lot Land Application Area Assessment	Daily water balance and nutrient balance modelling on a site specific basis used to derive average annual hydraulic and pollutant loads to surface and subsurface export routes for each general OSSM system LAA type.	LAA sized on most limiting balance (hydraulic / nutrient) with zero wet-weather storage requirements for all months.
Rainfall-Runoff	Average annual estimate of runoff volume using a volumetric coefficient of rainfall.	Calculated from Fletcher *et al.* (2004) for R = 1,200, C from Figure 2.3 (0.35) and <10% effective impervious area (EIA).
Surface and Subsurface Pollutant Export	Application of catchment attenuation factor (provided in Table 10-4 of the Technical Manual) to combined surface and subsurface on-site loads based on broad characteristics of the receiving environment. Mass balance combining attenuated on-site system flows and loads with catchment inputs.	DSM used to undertake daily water and nutrient (N and P) mass balance modelling to derive annual hydraulic and pollutant loads to surface (runoff) export routes.
Background Pollutant Loads / Concentrations	Sourced from Tables 2.44 - 2.45 or Figures 2.15 - 2.33 of Fletcher *et al.* (2004). Acceptable export rates/concentrations sourced from published local studies.	Reference background pollutant levels for existing land use conditions taken from Fletcher *et al.* (2004). Background (undeveloped) condition was inferred as 'forest' with 0% impervious (100% pervious). Proposed (development) condition was inferred as 'agricultural' with

		10% impervious (90% pervious).
Environment and Health Protection Targets	No more than 10% increase in average annual nitrogen and phosphorus loads (kg/yr) based on existing undeveloped backgrounds. Average virus concentrations <1MPN/100ml after application of attenuation rates. All LAAs sized to prevent hydraulic failure (surcharging) in 50% of years.	DSM outputs used to confirm compliance with targets against reference background values as previously described.

8.3 Modelling Overview

Available desktop and field data was used to build spatial model(s) to simulate hydrology, catchment pollutant export, OSSM system operation, and groundwater recharge/pollutant discharge and nutrient/pathogen attenuation in groundwater flow for the Site. The modelling operates on a daily time-step and has been parameterised using Site specific data to provide the best representation of actual conditions. The adopted modelling scenario assesses the long term sustainability of the preferred land application method of SSI on each proposed lot.

Modelling has been used to estimate the long-term hydraulic, nutrient and pathogen loads exported from the Site to show the difference between the existing (undeveloped) condition of the Site to the proposed (developed) condition, including indicative long-term average concentrations of Site runoff and groundwater discharge. It also provides an estimate of the frequency, magnitude and distribution of the surface failure of OSSM to assist in estimating local risks to human health and the environment.

In principle, the daily mass balance modelling simulates the water/pollutant balance process for the Site for the purpose of estimating long-term hydraulic, nutrient and pathogen loads discharging to receiving surface and groundwater. It should be noted that modelling is designed for use as a decision making tool and will not necessarily produce results that accurately reflect measured pollutant loads to receiving waters. Instead it aims to conduct a site mass balance to assess predicted increases in pollutant loads against existing conditions or alternative development concepts.

8.4 Rainfall-Runoff Estimation

Fletcher *et al.* (2004) was used to determine an average annual estimate of runoff volume from the Site using a volumetric coefficient of rainfall (as derived). The document includes a series of rainfall-runoff curves developed for different catchment areas 'typical' of coastal NSW. The Sydney template was assumed to be sufficiently representative of the local (Site) conditions. Figure 2.3 of Fletcher *et al.* was used to determine an appropriate rainfall-runoff coefficient. This value is then incorporated into a derived equation, along with (%) effective impervious area (EIA) to estimate the volume of runoff likely to occur from the Site on an annual basis.

Based on the mean annual rainfall for the Site (1,176mm) the R = 1,200 curve was used to derive an annual runoff coefficient (C) of 0.35. From this, it is estimated that the expected background (undeveloped) runoff from the Site is ~412mm/year (72.1ML/year) based on 0% Site imperviousness.

8.5 Decentralised Sewage Model (DSM)

The DSM was developed jointly by W&A and BMT WBM, for the purpose of providing a rapid-assessment tool to predict the performance of on-site and decentralised wastewater management systems under varying environmental conditions.

Background information and general methodology of the DSM is provided in the GTCC Technical Manual (2012) and the DSM User Manual (BMT WBM 2011).

8.5.1 DSM Overview

The DSM requires input of a range of bio-physical parameters. The resulting data from the monthly water balance, Digital Elevation Model (DEM) and soil grid created in MapInfo™ (v.10), and interpolated data from the SILO service Data Drill were used as inputs to the DSM to determine whether the two proposed OSSM system scenarios for the development at the Site would be sustainable. The model is able to predict OSSM performance by simulating the movement of pollutants (nitrogen, phosphorus and pathogens) within the effluent load as it travels from the point source (on-site or community-scale systems) down the catchment as surface or subsurface flows. The DSM does not predict the minimum area required to achieve zero surface runoff or deep drainage, instead, like the nominated area approach of the monthly water balance, the model predicts the surface and subsurface discharges based on a set of nominated conditions such as receiving node, soil, slope, weather, wastewater input and area.

8.5.2 DSM Modules Used

The DSM has five modules:

1. On-lot Performance Model (OLPM);
2. Particle Tracking Model (PTM);
3. Node-Link Model (NLM);
4. Central Management Components (CMC); and
5. Costing Model (CM)

Each module is able to be used in isolation or collectively depending on the needs of a project. For this project, only the OLPM and NLM modules were used. It is important to note that our application of the DSM makes the conservative assumption that the entire, non-attenuated pollutant load is transported through the catchment and that no dilution occurs within the receiving waters.

8.5.3 DSM Input Data

The DSM is designed to provide conservative estimates of OSSM system performance for the Site. The simulation was run for a period of 60 years (1954-2014) and represents a conservative estimate of long-term performance based on available information and a set of assumptions as detailed within this report. All site and soil assumptions have been drawn from the findings within the WWMP.

The key model input data are provided in Tables 9 and 10 below.

The proposed OSSM system scenario; STS with land application via SSI, was modelled to determine its suitability and sustainability. The OSSM system scenario input parameters were replicated for each of the proposed lots, with the appropriate LAA size applied to each lot.

Table 9: Site Input Data

Parameter	Unit	Value
Water supply	-	Town
Design wastewater load	L/day	1,200
Available EMA	m^2	≥900 (Lot 9)
LAA system	-	SSI
Nominated	m^2	780 (lots 4, 5, 6, 7, 8 and 9) 1,280 (lots 2, 3 and 10)
Storage type	-	No storage with fixed application rate
Storage volume	m^3	n/a
Design Loading Rate (DIR)	mm/day	3
Crop factor	-	0.55-0.85
Treatment quality	-	Secondary (with disinfection)
Effluent total nitrogen	mg/L	30
Effluent total phosphorus	mg/L	10
Effluent virus	MPN/100mL	10
Nitrogen crop uptake	kg/ha/yr	260
Phosphorus crop uptake	kg/ha/yr	30
Limiting soil horizon	-	Light Clay
Limiting soil depth	mm	600
Attenuation rate surface flow[1]	%	60
Attenuation rate phosphorus[1]	%	98
Attenuation rate nitrogen[1]	%	95
Attenuation rate viruses[1]	%	99
[1]Attentuation rates derived from Table 10.7 GTCC Technical Manual (2012)		

Table 10: Soil Input Data

Parameter	Code	Unit	Value	Source
Soil ID	-	-	ti	Based on Site soil analyses and SALIS technical report data.
Soil Water at Effective Saturation	SAT	mm	285	Published data for soil texture/structure.
Field capacity	FC	mm	120	Published data for soil texture/structure.
Permanent Wilting Point	PWP	% at 15kPa	17	Published data (Hazelton & Murphy, 2007).
Saturated hydraulic conductivity	SHC	mm/day	500	Published data (Hazelton & Murphy, 2007).
Soil depth for phosphorus sorption	SDP	mm	600	Field measurement; limiting layer, light clay subsoil.
Bulk density	BD	kg/m^3	1,500	Average value based on soil depth.
Initial depression storage	DS	mm	5	Initial loss before infiltration.
Dry soil infiltration rate	INF	mm/day	120	Published data for soil texture/structure.
Infiltration exponent	EXP1	dimensionless	3	Rate of infiltration decrease once soil gets wet Macleod (2008).
Freundlich adsorption coefficient	A1	g/L	205.0813	Phosphorus isotherm analysis. A1 is exp10 of intercept of isotherm with y axis; B1 is slope of log normal line; B2 is half of B1.
Freundlich adsorption exponent	B1	dimensionless	0.242049	
Freundlich desorption exponent	B2	dimensionless	0.121025	

8.6 DSM Results

Nutrient, hydraulic and pathogen load generation is divided into surplus loads discharged to the ground surface as 'surface surcharge' or draining below the root zone with subsequent groundwater flow to surface water bodies or aquifers as 'deep drainage'. The following sections outline the results of the modelling and their compliance with the required acceptance criteria.

8.6.1 Nutrient Loading

A summary of the predicted mean annual nutrient export to the receiving environment from the proposed LAAs is provided in Table 11 (full results are provided in Appendix F). The simulation was run for a period of 60 years (1954-2014). Tables 2.4.4 and 2.4.5 in Fletcher *et al.* (2004) were then used in conjunction with the predicted runoff volume to estimate background pollutant concentrations and loads. A land use of rural was adopted for the semi-cleared, unimproved pasture Site.

Table 11: Predicted Nutrient Export Results

Source	TP	TN
Background Load – Fletcher *et al.* (2004) (kg/yr)	4.35	64.89
DSM Surface Surcharge Export (kg/yr)	0	0
DSM Deep Drainage Export (kg/yr)	0.102	0.004
Total % increase from background levels	0.02	0.00

The results from the DSM modelling indicate that the predicted mean annual nutrient loads from the proposed subdivision (under the assumed development scenario) will represent a negligible increase (<1%) on the existing 'undeveloped' Site background nutrient loads. This demonstrates the appropriate sizing of the LAAs with all nutrients likely to be assimilated through vegetation uptake and in-soil processes.

The proposed subdivision and associated OSSM systems comply with the GTCC DAF (2012) acceptance requirement for less than a 10% increase on background nutrient export loads.

8.6.2 Hydraulic Loading

A summary of the predicted mean annual hydraulic export to the receiving environment from the proposed LAAs is provided in Table 12 (full results are provided in Appendix F). The simulation was run for a period of 60 years (1954-2014).

Table 12: Predicted Hydraulic Export Results

Source	Hydraulic Export
Mean Annual Surface Surcharge (m^3)	0
Mean Annual Deep Drainage (m^3)	947.63
Total (combined) LAA (m^2)	8,820

No surface surcharge is predicted for the average climate from the proposed LAAs. DAF acceptance criteria, reproduced in Table 7, states that all LAAs should be sized to prevent hydraulic failure (surcharging) in 50% of years.

Therefore, the proposed subdivision and associated OSSM systems meet the surface surcharge acceptance criterion.

Deep drainage (stored water moving out of the upper soil profile under gravity) from the Site is estimated at 947.63kL or 1076.44mm/yr. This equates to a mean of 0.29mm/day for the proposed development scenario, and 12.1% of the applied loading rate for slope limited sites (2.4mm/day).

W&A recommend that any value <50% of the applied loading rate is considered sustainable, with the majority of applied water being utilised through evapotranspiration or retained in soil storage.

8.6.3 Pathogen Loading

The DSM is also used to model the likely attenuation of pathogens (contained in wastewater) within the LAA. Viruses are selected as the preferred 'indicator' pathogen because they are shown to maintain the longest survival time in the environment and, because of their smaller size, are significantly more mobile in the soil water matrix. The transport and removal of viruses in effluent applied to soil is influenced by a number of factors that vary considerably with geographic scale. The DSM incorporates a number of empirically derived (first-order) decay equations to approximate physical and biological attenuation of pathogens in the soil environment, through such mechanisms as filtration, predation, desiccation and attrition. The pathogen transport model has used conservative input parameters to help ensure that it does not underestimate the ability of pathogens to be transported from the LAA on the Site. In cases where effluent is exported to groundwater by deep drainage or percolation, final polishing will be achieved within the unsaturated soils above the groundwater table.

The DSM reports pathogen (virus) numbers as 'most probable' concentrations (MPN/100mL) in both surface surcharge and deep drainage generated from the LAA. A summary of the predicted mean annual pathogen export to the receiving environment from the proposed LAA is provided in Table 13 (full results are provided in Appendix F). The simulation was run for a period of 60 years (1954-2014).

Table 13: Predicted Pathogen Export Results

Source	Pathogen Export
Surface Surcharge export (MPN/100mL)	0.000
Deep Drainage export (MPN/100mL)	0.000

Table 12 shows that pathogen export from the Site is expected to be significantly less than the GTCC DAF (2012) requirement of <1MPN/100mL under normal operating conditions.

Therefore, pathogen export from the combined LAAs under the proposed loading scenario is expected to be negligible.

8.6.4 Risk Summary

This Standard CIA addresses the various environmental and public health risks associated with the proposed and existing OSSM systems for the subdivision at the Site.

Both the proposed and existing SSI systems modelled in this CIA ensure that the potential for contaminant migration away from the LAAs is low and can demonstrate a reasonable expectation that, should very low levels of contaminants leave the immediate area of land application; they will be reduced to below background levels before reaching any sensitive receptors.

Modelling shows that predicted hydraulic loads for both systems are sustainable, with no surface surcharge expected and deep drainage limited to <50% of the effluent application rate. Also, it is shown that nutrients will be retained within the LAA and pathogens will be effectively attenuated well before they can reach groundwater.

Based on our analysis, the risk of nutrient, hydraulic and pathogen export to surface waters and groundwater posed by the proposed and existing SSI systems will not be significant. Appreciable impacts of effluent on neighbouring properties or adjacent land are considered unlikely, and OSSM will pose a low risk to public health and the environment.

9 Mitigation Measures

9.1 Stormwater Management

The performance of LAAs (and potentially treatment systems) can be adversely affected if stormwater is allowed to run onto these areas. This water should be diverted around the LAA through construction of upslope diversion drains. Typical construction details are presented in Figure 3 of Appendix A.

Any earth banks and drains should be stabilised as soon as possible to prevent erosion using vegetation or a suitable alternative. The outlet must be stabilised and must discharge water in a safe location where it will not create an erosion hazard or impact on structures or neighbouring properties. Any roof stormwater should be disposed of outside effluent management areas.

9.2 Vegetation Establishment and Management

Vegetation should be established within the each of the proposed LAAs. A complete vegetation cover is important to reduce the erosion hazard and optimise water and nutrient uptake. A good cover of turf grass will be suitable for both subsurface irrigation and Wisconsin Sand Mounds, as suggested in this report. Achieving a nutrient balance within a LAA relies on nutrients being taken up by vegetation and then exported with the cut vegetation (i.e. mown and clipping removed). This balance can only be maintained by removing the cut material from the area.

9.3 Soil Improvement

Site soils exhibit a calcium deficiency, as well as strong acidity within subsoils. This is typical of many east Australian soils, though Site investigations did not identify any significant impact to vegetative growth. Regardless, lime application within the LAA prior to system installation is recommended to increase the Calcium / Magnesium ratio and soil pH, while reducing the potential for soil structural degradation and dispersion. Lime is only slowly soluble in water so simply broadcasting it at the surface can be relatively difficult as it can take a long time for the calcium to penetrate the soil and reach the deeper soil layers. Therefore, it is necessary to incorporate lime into the soil during construction of the effluent management system. A suitable lime application rate of approximately 0.4kg/m^2 should be applied during construction.

10 Conclusions and Recommendations

Having undertaken detailed site and soil investigations, assessed the likely wastewater volumes and characteristics, and analysed the potential contamination risks, we conclude that on-site wastewater management is sustainable for the proposed subdivision development at the Site. Specifically, we recommend the following:

- it is evident that each of the proposed lots has the capacity to manage treated effluent from an assumed maximum five bedroom dwelling by either subsurface irrigation or Wisconsin mound, provided the selected application method is appropriately located, installed and operated;
- the preferred land application method of subsurface irrigation complies with the GTCC DAF (2012) standard cumulative impact assessment requirements, and therefore is not expected to present a risk to human and environmental health;
- for proposed Lots 2, 3 and 10, secondary treated effluent may be discharged to a subsurface irrigation field of no less than 1,280m^2 to assimilate the anticipated daily hydraulic load from a five bedroom dwelling;
- for proposed Lots 4, 5, 6, 7, 8 and 9, secondary treated effluent may be discharged to a subsurface irrigation field of no less than 780m^2 to assimilate the anticipated daily hydraulic load from a five bedroom dwelling;
- for all proposed lots where the selected land application method is via a Wisconsin Sand Mound, the final positioning of the mound must be positioned across the natural ground contour on slope ≤15%;
- the preferred land application areas are located on the relatively lower gradient pasture areas on each proposed, within practical distances of building envelopes. They comply with adopted setbacks from surface waters, property boundaries (AS/NZS 1547:2012) and other improvements;
- the selected secondary wastewater treatment system should be installed by an experienced professional, taking into account the expected flows and other recommendations contained within this report;
- stormwater run-on must be directed away from the proposed LAA using a stormwater diversion drain; and
- vehicles and grazing animals must be prevented from entering the designated LAA. The area may need to be fenced or otherwise defined to ensure this is observed.

This completes our assessment of the capability of the proposed subdivision at Lot 2 DP 1120671 Alpine Drive, Tinonee for on-site wastewater management.

Please do not hesitate to contact me on 02 4954 4996 if you have any questions.

11 References (Cited and Used)

Fletcher, T., Duncan, H., Poelsma, P. & Lloyd, S. *Stormwater Flow and Quality, and the effectiveness of non-proprietary stormwater treatment measures – a review and gap analysis* Technical Report 04/8 December 2004, Cooperative Research Centre for Catchment Hydrology.

Hazelton, P. & Murphy, B. (2007) Interpreting Soil Test Results, What to all the numbers mean? CSIRO Publishing, Victoria.

NSW DECCW (2004). Environmental Guidelines – Use of Effluent by Irrigation. NSW Department of Environment and Conservation, Sydney.

NSW Department of Local Government et al. (1998). Environment & Health Protection Guidelines: On-site Sewage Management for Single Households.

Patterson, R.A. (2002). 'Workshop 2 – Calculations for Nutrient Balances.' In Evaluating Site and Soil Assessment Reports for On-site Wastewater Systems. A one-day training course held in Fairfield, Sydney. Centre for Environment Training, Cardiff Heights NSW. March 2002.

Patterson, R.A. (2003). Nitrogen in Wastewater and its Role in Constraining On-Site Planning. In Patterson & Jones (Eds.) Proceedings of On-site '03 Conference: Future Directions for On-site Systems: Best Management Practice. Lanfax Laboratories, Armidale.

Patterson, R.A. (2006). Consideration of soil salinity when assessing land application of effluent greywater. Septic Safe Technical Note 01/6, NSW Department of Local Government, Sydney.

Greater Taree City Council (2012). Onsite Sewage Management Technical Manual (Final).

Greater Taree City Council (2012). Onsite Sewage Development Assessment Framework (DAF).

Standards Australia / Standards New Zealand (2012). AS/NZS 1547:2012 On-site Domestic-wastewater Management.

Appendix A

Figures & Site Plans

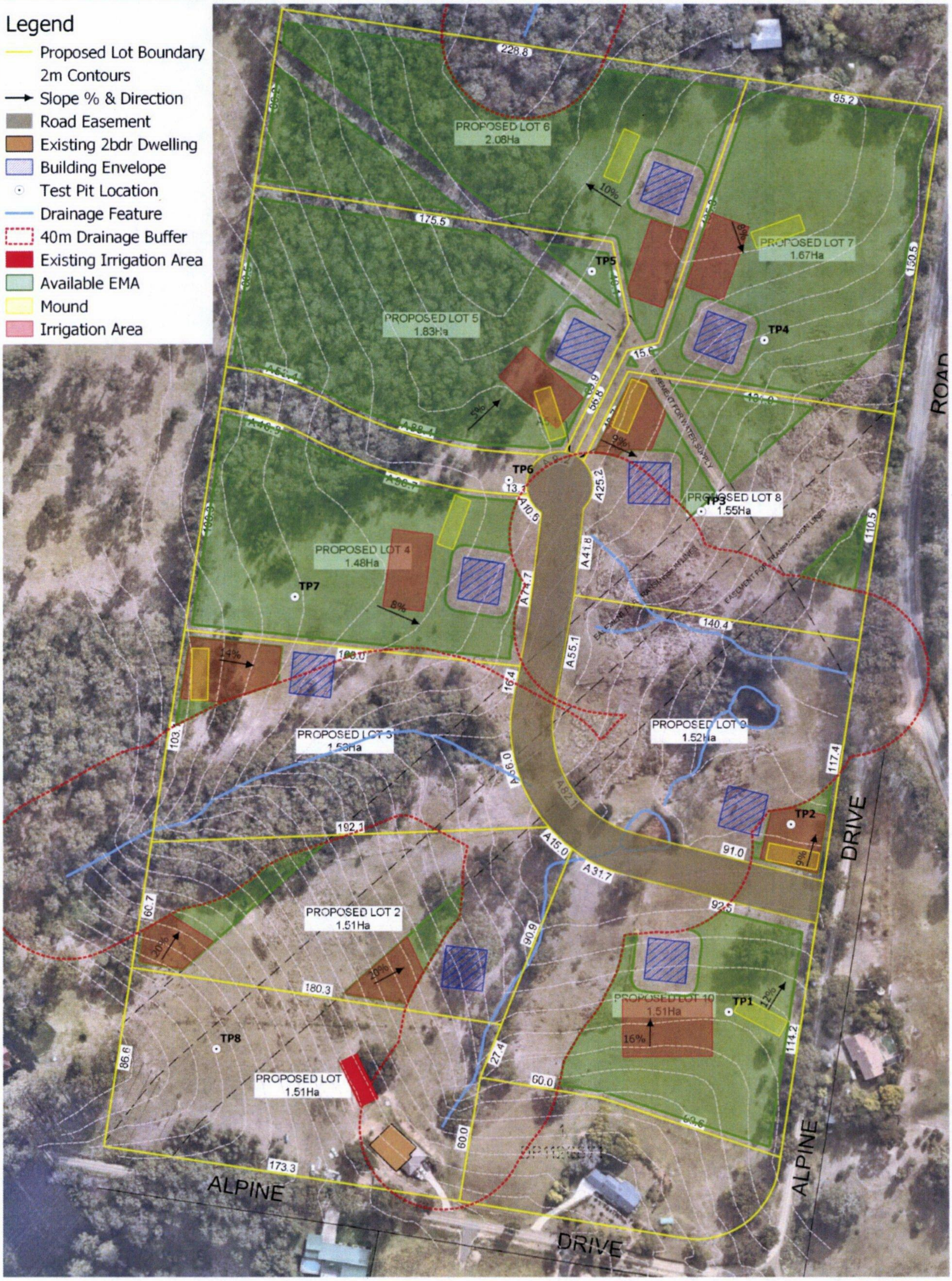


Figure 1: Site Plan Showing Available Effluent Management Areas

1308 - WWMP for Proposed Subdivision at Tinonee, NSW

Whitehead & Associates Environmental Consultants

0 40 80 120 160 200 m (Approx Scale)

Revision	4
Drawn	NB
Approved	MS

Cross Section: Upslope Diversion Drain

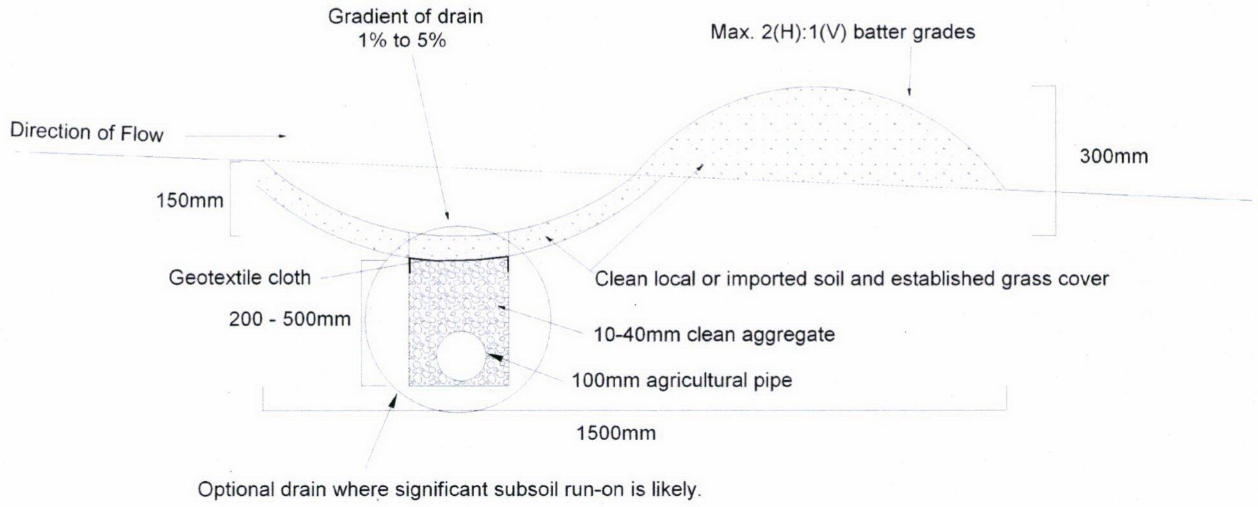


Figure 3: Construction Diagram - Upslope Diversion Drain

Wastewater Management Plan - Lot 2 DP 1120671, Alpine Drive Tinonee

Whitehead & Associates Environmental Consultants

(Not to Scale - Dimensions as Specified)

Revision	1
Drawn	NB
Approved	MS

Appendix B

Soil Borelogs

Whitehead & Associates
Environmental Consultants

Key to Soil Borelogs

Symbols

W	Watertable depth	●	Sample collected
X	Depth of refusal		

Moisture condition

D	Dry
SM	Slightly moist
M	Moist
VM	Very moist
W	Wet / saturated

Graphic Log and Textures

S - Sand
LS - Loamy sand
CS - Clayey sand

CL - Clay loam
SCL - Sandy clay loam
SiCL - Silty clay loam

Gravel (G)

SL - Sandy loam

LC - Light clay
SC - Sandy clay
SiC - Silty clay

Parent material (stiff)

L - Loam
LFS - Loam fine sandy
SiL - Silty loam

MC - Medium clay
HC - Heavy clay

Parent material (weathered)

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	Robert and Sharon O'Hara	**Test Pit No:**	**TP1**
Site:	Lot 2 DP 1120671 Alpine Drive, Tinonee	Excavated/logged by:	N Banbrook
Date:	1 August 2014	Excavation type:	Hand Auger / Shovel
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1–0.5		TP 1/1	A1	CL	moderate pedality	dark brown 7.5YR 3/3	nil	<2%	D	many fine roots
0.6–0.8		TP 1/2	A2	CL	moderate to weak pedality	dark brown 7.5YR 3/3	nil	<10%	D	
0.9–1.5		Test pit terminated at 0.8m depth								

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	Robert and Sharon O'Hara	**Test Pit No:**	**TP2**
Site:	Lot 2 DP 1120671 Alpine Drive, Tinonee	Excavated/logged by:	N Banbrook
Date:	1 August 2014	Excavation type:	Hand Auger / Shovel
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 2/1	A1	CL	moderate pedality	dark brown 7.5YR 3/2	nil	25%	D	many fine roots
0.2		TP 2/2	A2	CL	moderate to weak pedality	dark brown 7.5YR 3/2	nil	25% gravel and cobbles	D	some fine roots
0.3										
0.4										
0.5										
0.6										
0.7		Refusal at 0.6m depth on cobbles								
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										

Soil Bore Log

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	Robert and Sharon O'Hara	**Test Pit No:**	**TP3**
Site:	Lot 2 DP 1120671 Alpine Drive, Tinonee	Excavated/logged by:	N Banbrook
Date:	1 August 2014	Excavation type:	Hand Auger / Shovel
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 3/1	A1	CL	weak pedality	very dark brown 7.5YR 2.5/2	nil	5%	SM	many fine roots
0.2		TP 3/2	A2	CL	weak pedality	very dark brown 7.5YR 2.5/2	nil	10%	D	some fine roots
0.3										
0.4										
0.5										
0.6										
0.7		Refusal at 0.6m depth on dry hard pan								
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	Robert and Sharon O'Hara	**Test Pit No:**	**TP4**
Site:	Lot 2 DP 1120671 Alpine Drive, Tinonee	Excavated/logged by:	N Banbrook
Date:	1 August 2014	Excavation type:	Hand Auger / Shovel
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 4/1	A1	CL	weak pedality	very dark brown 7.5YR 2.5/2	nil	30%	D	many fine roots
0.2										
0.3										
0.4		TP 4/2	A2	SCL	weak pedality	dark yellow brown 10YR 3/6	nil	30% gravel and cobbles	D	some fine roots
0.5										
0.6										
0.7		Refusal at 0.6m depth on cobbles								
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	Robert and Sharon O'Hara	**Test Pit No:**	**TP5**
Site:	Lot 2 DP 1120671 Alpine Drive, Tinonee	Excavated/logged by:	N Banbrook
Date:	1 August 2014	Excavation type:	Hand Auger / Shovel
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 5/1	A1	CL	weak pedality	very dark brown 7.5YR 2.5/2	nil	10%	D	many fine roots
0.2										
0.3										
0.4		TP 5/2	A2	CL	weak pedality	very dark brown 7.5YR 2.5/2	nil	10% gravel and cobbles	D	
0.5										
0.6										
0.7		Refusal at 0.6m depth on cobbles								
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	Robert and Sharon O'Hara	**Test Pit No:**	**TP6**
Site:	Lot 2 DP 1120671 Alpine Drive, Tinonee	Excavated/logged by:	N Banbrook
Date:	1 August 2014	Excavation type:	Hand Auger / Shovel
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 6/1	A1	CL	weak pedality	very dark brown 7.5YR 2.5/2	nil	10%	D	many fine roots
0.2										
0.3		TP 6/2	A2	CL	weak pedality	dark yellow brown 10YR 4/4	nil	20% gravel and cobbles	D	
0.4										
0.5										
0.6		TP 6/3	B	LC	well structured subangular blocky peds	dark yellow brown 10YR 4/4	some yellow and orange	25% gravel and cobbles	D	
0.7										
0.8										
0.9										
1.0										
1.1		Test pit terminated at 1.0m depth								
1.2										
1.3										
1.4										
1.5										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	Robert and Sharon O'Hara	**Test Pit No:**	**TP7**
Site:	Lot 2 DP 1120671 Alpine Drive, Tinonee	Excavated/logged by:	N Banbrook
Date:	1 August 2014	Excavation type:	Hand Auger / Shovel
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 7/1	A1	CL	weak pedality	dark brown 10YR 3/3	nil	5%	D	many fine roots
0.2										
0.3		TP 7/2	A2	CL	weak pedality	dark brown 10YR 3/3	nil	10% gravel and cobbles	D	
0.4					pedality	10YR 3/3		gravel and cobbles		
0.5										
0.6		Refusal at 0.5m depth on cobbles								
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants Pty Ltd

Client:	Robert and Sharon O'Hara	**Test Pit No:**	**TP8**
Site:	Lot 2 DP 1120671 Alpine Drive, Tinonee	Excavated/logged by:	N Banbrook
Date:	1 August 2014	Excavation type:	Hand Auger / Shovel
Notes:			

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 8/1	A1	CL	weak pedality	very dark brown 10YR 2/2	nil	25% gravel and cobbles increasing with depth	D	many fine roots
0.2										
0.3										
0.4										
0.5										
0.6										
0.7		Refusal at 0.6m depth on cobbles								
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										

Appendix C

Raw Soil Data and Analytical Results

Sheet 1 - Soil Sampling Schedule and Results of pH, EC and Emerson Aggregate Test Analysis

Site	Sample Name	Sample Depth (mm)	Texture Class	EAT [1]	Rating [2]	pH f [3]	pH 1:5 [4]	Rating	EC 1:5 (µS/cm)	ECe (dS/m) [5]	Rating	Other analysis [6]
TP1 - A1	1/1	500	CL	5	Low	n/a	5.9	Moderately acid	33	0.30	Non-saline	
TP1 - A2	1/2	800	CL	5	Low	n/a	5.9	Moderately acid	16	0.14	Non-saline	
TP2 - A1	2/1	150	CL	2	High	n/a	5.6	Moderately acid	7	0.06	Non-saline	
TP2 - A2	2/2	600	CL	2	High	n/a	5.5	Strongly acid	5	0.05	Non-saline	
TP3 - A1	3/1	150	CL	2	High	n/a	5.6	Moderately acid	5	0.05	Non-saline	
TP3 - A2	3/2	300	CL	2	High	n/a	5.6	Moderately acid	4	0.04	Non-saline	
TP4 - A1	4/1	300	CL	2	High	n/a	5.5	Strongly acid	4	0.04	Non-saline	
TP4 - A2	4/2	600	CL	2	High	n/a	5.6	Moderately acid	7	0.06	Non-saline	
TP5 - A1	5/1	300	CL	5	Low	n/a	5.4	Strongly acid	5	0.05	Non-saline	
TP5 - A2	5/2	600	MC	2	High	n/a	5.3	Strongly acid	2	0.01	Non-saline	
TP6 - A1	6/1	200	CL	6	Low	n/a	5.4	Strongly acid	1	0.01	Non-saline	
TP6 - A2	6/2	500	CL	2	High	n/a	5.3	Strongly acid	2	0.02	Non-saline	
TP6 - B	6/3	1000	LC	2	High	n/a	5.1	Strongly acid	7	0.06	Non-saline	
TP7 - A1	7/1	200	CL	2	High	n/a	5.4	Strongly acid	4	0.04	Non-saline	
TP7 - A2	7/2	500	LC	2	High	n/a	5.4	Strongly acid	5	0.04	Non-saline	
TP8 - A1	8/1	600	CL	2	High	n/a	5.5	Strongly acid	11	0.10	Non-saline	

Notes:- (also refer Interpretation Sheet 1)

[1] The modified Emerson Aggregate Test (EAT) provides an indication of soil susceptibility to dispersion.

[2] Ratings describe the likely hazard associated with land application of treated wastewater.

[3] pH measured in the field using Raupac Indicator.

[4] pH measured on 1:5 soil:water suspensions using a *Hanna Combo* hand-held pH/EC/temp meter.

[5] Electrical conductivity of the saturated extract (ECe) = $EC_{1:5}$(µS/cm) x MF / 1000. Units are dS/m. MF is a soil texture multiplication factor.

[6] External laboratories used for the following analyses, if indicated:

- CEC (Cation exchange capacity)
- Psorb (Phosphorus sorption capacity)
- Bray Phosphorus
- Organic carbon
- Total nitrogen

Sheet 2 - Results of External Laboratory Analysis

Site	Name	Depth (mm)	CEC (me/100g)	Rating	Ca (mg/kg)	Rating	Mg (mg/kg)	Rating	Na (mg/kg)	Rating	K (mg/kg)	Rating	ESP (%)	Rating	P-sorp. (mg/kg)	Rating
1308	TP4 - Composite	600	6.5	L	517	L	237	M	40	L	90	L	2.7	NS	467	H
1308	TP6 - Composite	1000	9.2	L	120	VL	385	H	99	M	51	VL	4.7	NS	546	H
1308	TP8 - Composite	600	8.9	L	863	L	304	M	10	VL	338	H	0.5	NS	353	MH

Phone Office/Lab (02) 6775 1157
Fax (02) 6775 1043
email: lanfaxlabs@bigpond.com.au
Website: http://www.lanfaxlabs.com.au
Lab address: 493 Old Inverell Road
Postal address: PO Box 4690 Armidale NSW 2350
Director: Dr Robert Patterson FIEAust, CPSS, CPAg
Soil Scientists and Environmental Engineers

Lanfax Laboratories
ABN 72 212 385 096
ASPAC
Proficiency tested by Aust. Soil & Plant Analysis Council Inc.

18th August 2014

Whitehead & Associates
197 Main Road
Cardiff NSW 2285

Soil Report: Job No. Project 1308, three samples
Samples received 11th August 2014. Sample date not stated
Samples dried to 50°C, crushed and sieved to minus 2 mm prior to analysis

Whitehead & Assoc. Project 1308 AUG14

Exc.Al+ H	Ca		K		Mg		Na		Base Sat.	ESP	CEC	Ca/Mg	Site Location
cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	%	%	cmol+/kg	ratio	Sample ID
1.60	517	2.58	90	0.23	237	1.95	40	0.17	75.5	2.7	6.5	1.3	1308 - TP 4
4.88	120	0.60	51	0.13	385	3.16	99	0.43	47.0	4.7	9.2	0.2	1308 - TP 6
1.20	863	4.30	338	0.87	304	2.50	10	0.05	86.5	0.5	8.9	1.7	1308 - TP 8

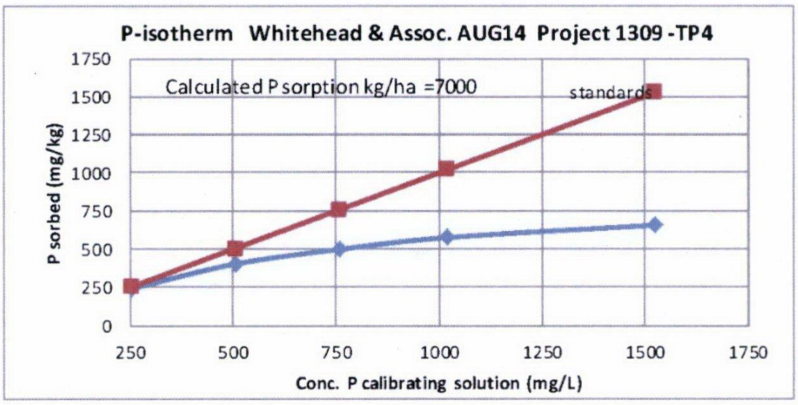
Methods: Rayment & Lyons 2011
P sorption modified method 9J1 - elevated equilibrating solutions, ICP determination of P
Cations: Method 15D3, no pretreatment
Exchangeable Acidity: Method 15G1

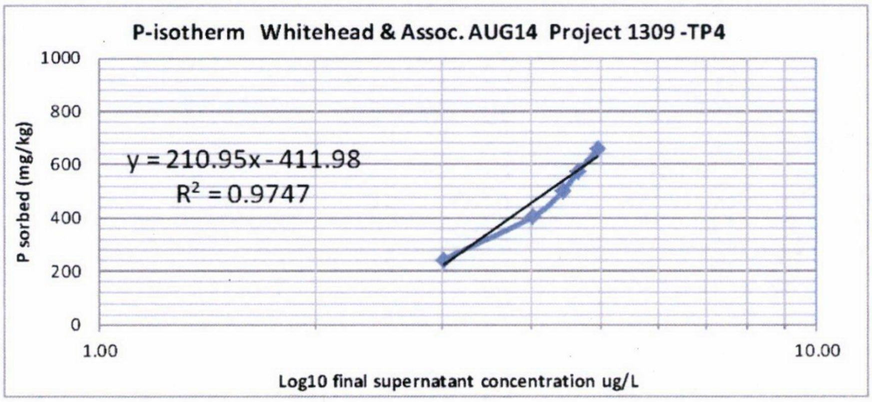
Yours faithfully,

RHPatterson

Dr Robert Patterson FIEAust, CPSS(3), CPAg
Soil Scientist and Environmental Engineer

Commercial and research laboratory for soil, water and plant analysis.
Soil survey and analytical assessments, landscape analysis and plant nutrient relationships,
Wastewater and effluent reuse specialists - on-site and decentralised



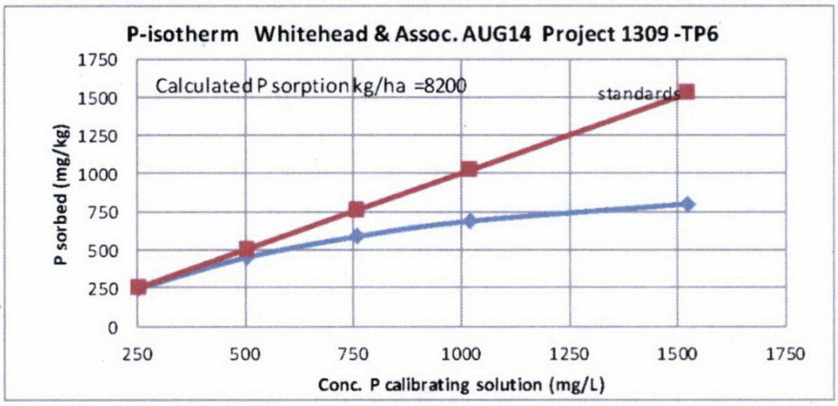


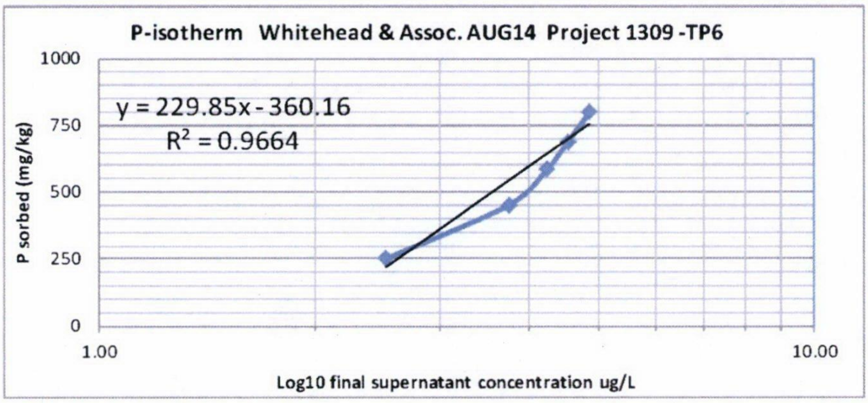
Percent sorbed is the proportion of the initial P sorbed during equilibration

P-isotherm Whitehead & Assoc. AUG14 Pr

Initial P	filtrate	sorbed P	Sample	Percent	Std line	filtrate	Y axis	X axis
mgP/L	P	mg/kg	I.D.	sorbed		C	Log C	
	mg/L			(%)		ugP/L		
25.3	1.02	243.0	Whitehead & Assoc. AUG14	96.0	253	1023	3.01	243.0
50.6	10.31	402.7	Project 1309 -TP4	79.6	506	10310	4.01	402.7
76.0	26.09	498.6		65.6	760	26090	4.42	498.6
102.0	44.46	575.4		56.4	1020	44460	4.65	575.4
152.4	86.80	656.0		43.0	1524	86800	4.94	656.0

Calculated P sorption kg/ha = 7000



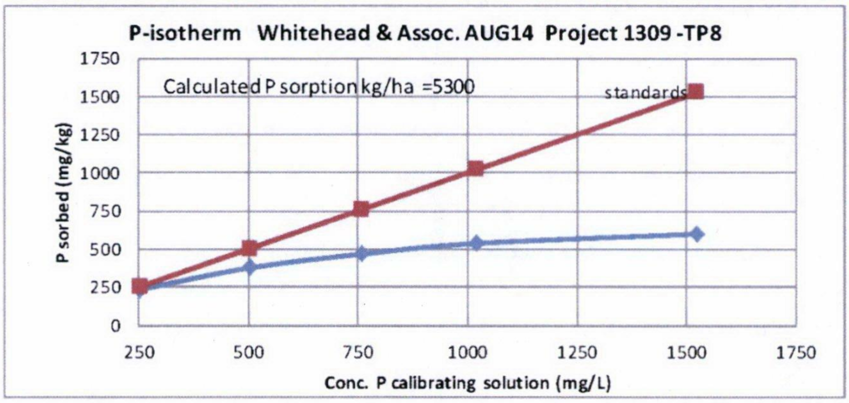


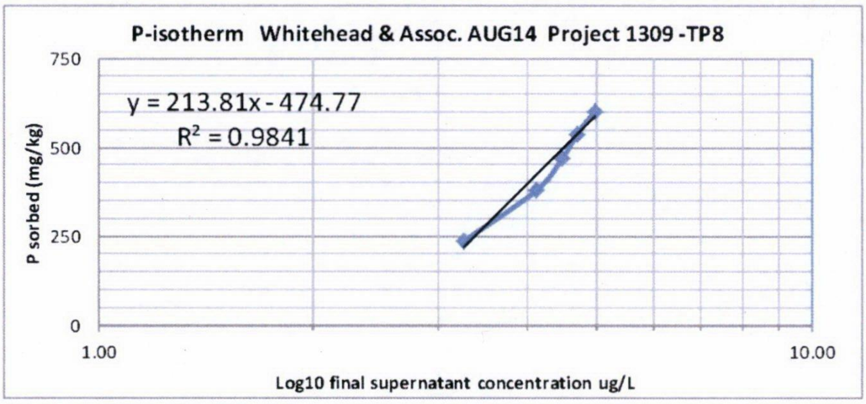
Percent sorbed is the proportion of the initial P sorbed during equilibration

P-isotherm Whitehead & Assoc. AUG14 Pı

Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)		Std line	filtrate C ugP/L	Y axis Log C	X axis
25.3	0.33	249.9	Whitehead & Assoc. AUG14	98.7		253	332	2.52	249.9
50.6	5.55	450.3	Project 1309 -TP6	89.0		506	5549	3.74	450.3
76.0	17.40	585.5		77.1		760	17400	4.24	585.5
102.0	33.39	686.1		67.3		1020	33390	4.52	686.1
152.4	72.50	799.0		52.4		1524	72500	4.86	799.0

Calculated P sorption kg/ha = 8200





Percent sorbed is the proportion of the initial P sorbed during equilibration

P-isotherm Whitehead & Assoc. AUG14 Pr

Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)	Std line	filtrate C ugP/L	Y axis Log C	X axis
25.3	1.79	235.3	Whitehead & Assoc. AUG14	92.9	253	1788	3.25	235.3
50.6	12.78	378.0	Project 1309 -TP8	74.7	506	12780	4.11	378.0
76.0	29.23	467.2		61.5	760	29230	4.47	467.2
102.0	48.30	537.0		52.6	1020	48300	4.68	537.0
152.4	92.40	600.0		39.4	1524	92400	4.97	600.0

Calculated P sorption kg/ha = 5300

Appendix D

Water & Nutrient Balance Modelling

Nominated Area Water Balance & Storage Calculations

Site Address: Lot 2 DP1120671 Alpine Drive, Tinonee

INPUT DATA

Design Wastewater Flow	Q	1,200	L/day	
Design Irrigation Rate	DIPR	21	mm/week	
Daily DIR		3.0	mm/day	L/m^2/day - Based on Table M1 & M2 AS/NZS 1547:2012 with a 20% reduction for slope
Nominated Land Application Area	L	780	m sq	
Crop Factor	C	0.6-0.8	unitless	Estimates evapotranspiration as a fraction of pan evaporation; varies with season and crop type
Runoff Coefficient		0.8	unitless	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Rainfall Data	Taree - Technical Manual			Mean Monthly Data
Evaporation Data	Taree - Technical Manual			Mean Monthly Data

Flow Allowance	150	L/p/d
No. of bedrooms	5	
Occup Rate	1.6	

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Days in month	D	\	days	31	28	31	30	31	30	31	31	30	31	30	31	**365**
Rainfall	R	\	mm/month	118.9	138.7	149.5	117	96.8	97.7	73.9	61.2	60.2	75.6	86.6	99.9	**1,176.0**
Evaporation	E	\	mm/month	176.7	142.8	130.2	96	65.1	57	58.9	80.6	111	142.6	159	186	**1,405.9**
Daily Evaporation				5.7	5.1	4.2	3.2	2.1	1.9	1.9	2.6	3.7	4.6	5.3	6	
Crop Factor	C			0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.60	0.65	0.70	0.75	0.80	
OUTPUTS																
Evapotranspiration	ET	ExC	mm/month	150	114	98	67	42	34	32	48	72	100	119	149	**1,026.6**
Percolation	B	(DPR/7)xD	mm/month	93.0	84	93.0	90.0	93.0	90.0	93.0	93.0	90.0	93.0	90.0	93.0	**1,095.0**
Outputs		ET+B	mm/month	243.2	198.24	190.7	157.2	135.3	124.2	125.4	141.4	162.2	192.8	209.3	241.8	**2,121.6**
INPUTS																
Retained Rainfall	RR	R*runoff coef	mm/month	95.12	110.96	119.6	93.6	77.44	78.16	59.12	48.96	48.16	60.48	69.28	79.92	**940.8**
Effluent Irrigation	W	(QxD)/L	mm/month	47.7	43.1	47.7	46.2	47.7	46.2	47.7	47.7	46.2	47.7	46.2	47.7	**561.5**
Inputs		RR+W	mm/month	142.8	154.0	167.3	139.8	125.1	124.3	106.8	96.7	94.3	108.2	115.4	127.6	**1,502.3**
STORAGE CALCULATION																
Storage remaining from previous month			mm/month	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	
Storage for the month	S	(RR+W)-(ET+B)	mm/month	-100.4	-44.2	-23.4	-17.4	-10.2	0.1	-18.6	-44.7	-67.8	-84.6	-93.8	-114.2	**-158.4**
Cumulative Storage	M		mm	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	**0.1**
Maximum Storage for Nominated Area	N		mm	**0.11**												
	V	NxL	L	**89**												
LAND AREA REQUIRED FOR ZERO STORAGE			m^2	251	385	524	566	643	782	561	403	316	281	257	230	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: **782** m^2

Nominated Area Water Balance & Storage Calculations

Site Address: Lot 2 DP1120671 Alpine Drive, Tinonee

INPUT DATA

Design Wastewater Flow	Q	1,200	L/day	
Design Irrigation Rate	DIPR	16.8	mm/week	
Daily DIR		2.4	mm/day	L/m²/day - Based on Table M1 & M2 AS/NZS 1547:2012 with a 20% reduction for slope
Nominated Land Application Area	L	1,280	m sq	
Crop Factor	C	0.6-0.8	unitless	Estimates evapotranspiration as a fraction of pan evaporation; varies with season and crop type
Runoff Coefficient		0.8	untiless	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Rainfall Data	Taree - Technical Manual			Mean Monthly Data
Evaporation Data	Taree - Technical Manual			Mean Monthly Data

Flow Allowance	150	L/p/d
No. of bedrooms	5	
Occup Rate	1.6	

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Days in month	D	\	days	31	28	31	30	31	30	31	31	30	31	30	31	**365**
Rainfall	R	\	mm/month	118.9	138.7	149.5	117	96.8	97.7	73.9	61.2	60.2	75.6	86.6	99.9	**1,176.0**
Evaporation	E	\	mm/month	176.7	142.8	130.2	96	65.1	57	58.9	80.6	111	142.6	159	186	**1,405.9**
Daily Evaporation				5.7	5.1	4.2	3.2	2.1	1.9	1.9	2.6	3.7	4.6	5.3	6	
Crop Factor	C			0.85	0.80	0.75	0.70	0.65	0.60	0.55	0.60	0.65	0.70	0.75	0.80	
OUTPUTS																
Evapotranspiration	ET	ExC	mm/month	150	114	98	67	42	34	32	48	72	100	119	149	**1,026.6**
Percolation	B	(DPR/7)xD	mm/month	74.4	67.2	74.4	72.0	74.4	72.0	74.4	74.4	72.0	74.4	72.0	74.4	**876.0**
Outputs		ET+B	mm/month	224.6	181.44	172.1	139.2	116.7	106.2	106.8	122.8	144.2	174.2	191.3	223.2	**1,902.6**
INPUTS																
Retained Rainfall	RR	R*runoff coef	mm/month	95.12	110.96	119.6	93.6	77.44	78.16	59.12	48.96	48.16	60.48	69.28	79.92	**940.8**
Effluent Irrigation	W	(QxD)/L	mm/month	29.1	26.3	29.1	28.1	29.1	28.1	29.1	29.1	28.1	29.1	28.1	29.1	**342.2**
Inputs		RR+W	mm/month	124.2	137.2	148.7	121.7	106.5	106.3	88.2	78.0	76.3	89.5	97.4	109.0	**1,283.0**
STORAGE CALCULATION																
Storage remaining from previous month			mm/month	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	
Storage for the month	S	(RR+W)-(ET+B)	mm/month	-100.4	-44.2	-23.4	-17.5	-10.2	0.1	-18.6	-44.7	-67.9	-84.7	-93.8	-114.2	**-158.6**
Cumulative Storage	M		mm	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	**0.1**
Maximum Storage for Nominated Area	N		mm	**0.09**												
	V	NxL	L	**109**												
LAND AREA REQUIRED FOR ZERO STORAGE			m²	287	477	709	789	947	1284	780	504	375	327	295	260	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: 1,284 m²

Nutrient Balance

Site Address: Lot 2 DP1120671 Alpine Drive, Tinonee

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 709 m^2

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	1,200	L/Day	Crop N Uptake	260	kg/ha/yr	which equals	71	mg/m²/day
Effluent N Concentration	30	mg/L	Crop P Uptake	30	kg/ha/yr	which equals	8	mg/m²/day
% Lost to Soil Processes (Geary & Gardner 1996)	0.2	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil	7,200	mg/day	P-sorption result	353	mg/kg	which equals	3,180	kg/ha
Remaining N Load after soil loss	28,800	mg/day	Bulk Density	1.5	g/cm3		or	
Effluent P Concentration	10	mg/L	Depth of Soil	0.6	m		3,180	kg/ha
Design Life of System	50	yrs	% of Predicted P-sorp. [2]	0.5	Decimal		353.3	mg/kg

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer			Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)		
Nitrogen	404.31	m²	Nominated LAA Size	1,280.00	m²
Phosphorus	708.77	m²	Predicted N Export from LAA	-22.77	kg/year
			Predicted P Export from LAA	-3.53	kg/year
			Phosphorus Longevity for LAA	377	Years
			Minimum Buffer Required for excess nutrient	0	m²

PHOSPHORUS BALANCE

STEP 1: Using the nominated LAA Size

Nominated LAA Size	**1,280**	m²			
Daily P Load	0.012	kg/day	→ Phosphorus generated over life of system	219	kg
Daily Uptake	0.0105205	kg/day	→ Phosphorus vegetative uptake for life of system	0.150	kg/m²
Measured p-sorption capacity	0.31797	kg/m²			
Assumed p-sorption capacity	0.159	kg/m²	→ Phosphorus adsorbed in 50 years	0.159	kg/m²
Site P-sorption capacity	203.50	kg	→ Desired Annual P Application Rate	7.910	kg/year
			which equals	0.02167	kg/day
P-load to be sorbed	0.54	kg/year			

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. Conservative estimate based on work by Geary & Gardner (1996) and Patterson (2002).

[3]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Sand Mound Sizing Sheet — Version 11 — 31-Aug-12

Site Address: Lot 2 DP1120671

Scenario: New Dwelling

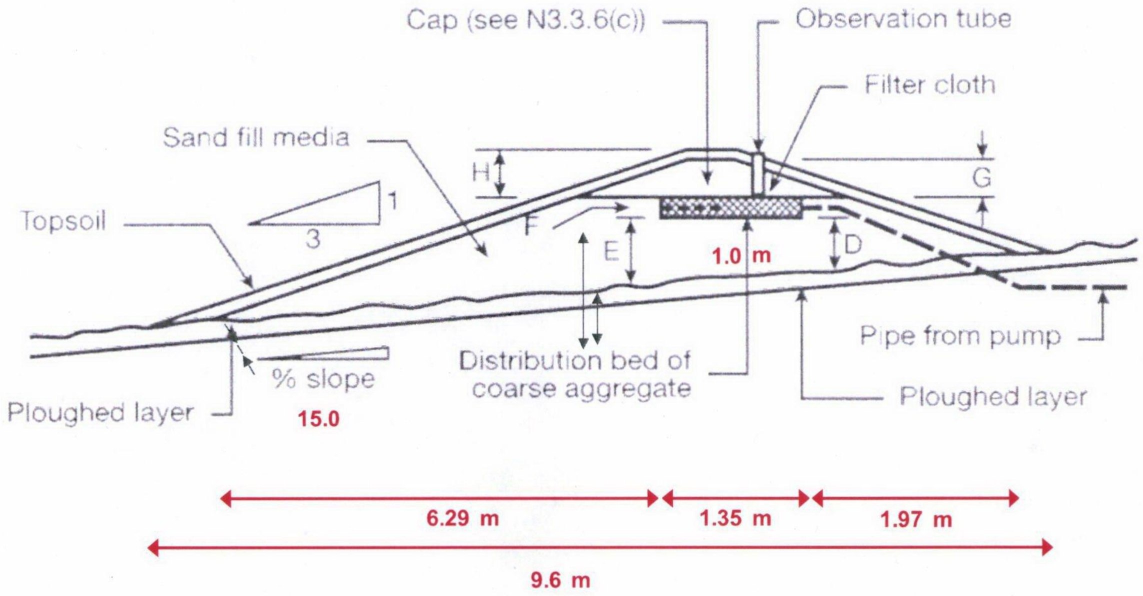
Notes for using this Sheet:
1. The reference notes numbered below are provided in the accompanying explanation sheet.
2. User-input variables are in **green cells**. Values in **red text** are calculated - do not modify!

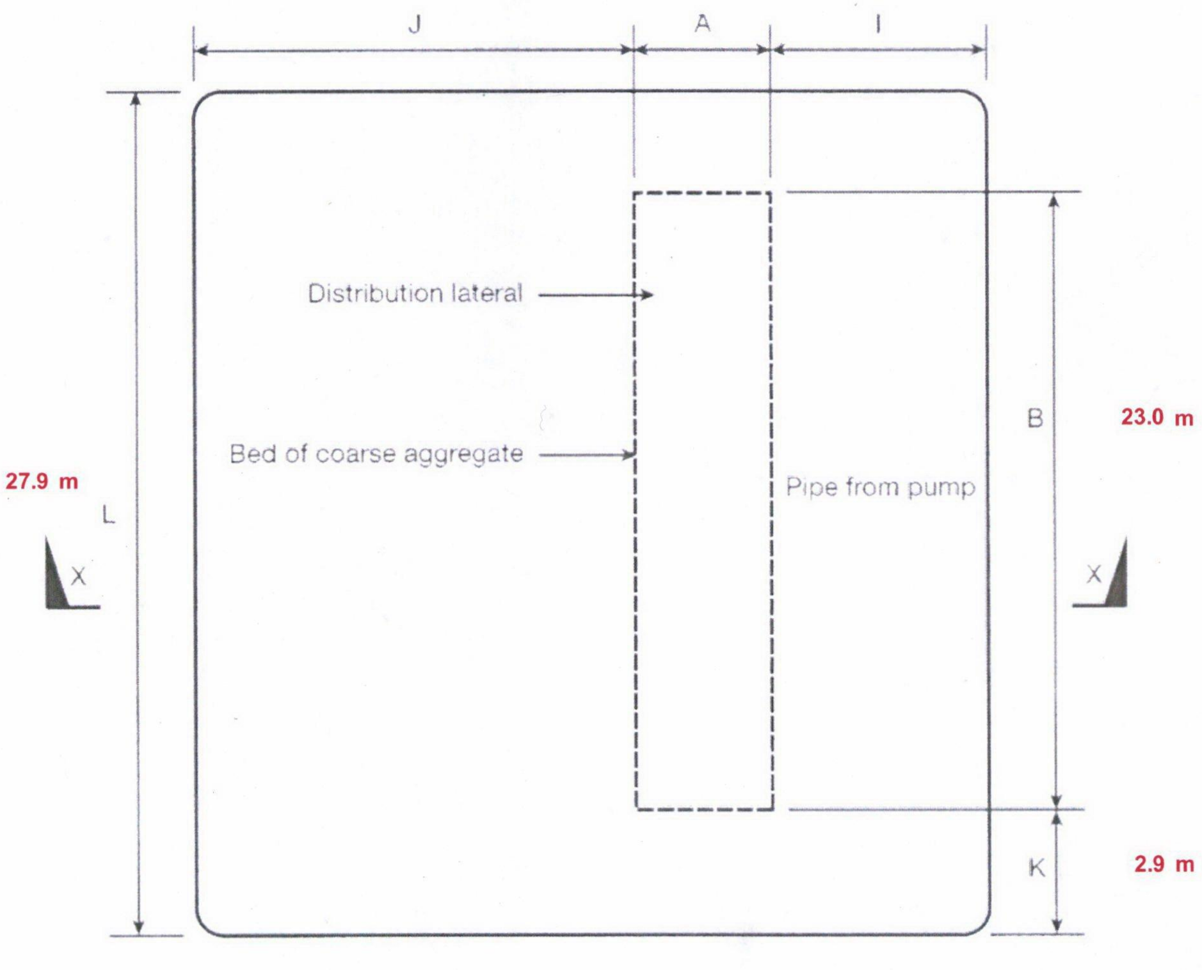
Notes	Site Data	Symbol	Value		
	Daily wastewater load (L/day)	W	1,200		
	Effluent Quality (P = primary, S = secondary)	Q	P		
	Soil texture (topsoil)		CL		
1	Soil depth to limiting layer (m)	SD	0.50		
2	Natural slope across basal area (%)	NS	15.0		
3	Natural slope in radians (rad)	α	0.1		
4	Recommended basal loading rate (mm/day)	BLR	8.0		
5	Recommended linear loading rate (L/m/day)	LLR	54.0		
6	Recommended minimum separation from limiting layer (m)	SLL	1.0		
7	Sand loading rate at gravel-sand interface (mm/day)	SLR	40.0		
	Calculations	**Symbol**	**Formula**	**Value**	**Key**
8	Recommended mound batter slope (H:V) (e.g. 3, 2.5)	BS	nominated	3.00	
	Batter slope in radians (rad)	ϕ		0.32	
	Gravel bed dimensions:				
9	Length (m)	B	W / LLR	22.22	
10	Width (m)	A	LLR / SLR	1.35	
	Thickness (m)	F	nominated	0.25	
11	Minimum capping over gravel at the edges (m)	G	nominated	0.20	
12	Topsoil cover all over (m)	C	nominated	0.10	
13	Recommended minimum sand depth (upslope) (m)	D_u	SLL - SD; min. 0.6 for primary effluent (0.4 for secondary)	0.40	D
	Downslope mound fill depth (m)	D_d	D_u + (NS × A)	0.60	E
	Fill depth at centre of gravel bed (m)	D_c	(D_u + D_d) / 2	0.50	
14	Theoretical capping depth at centre of peaked mound (m)	P_1	G + [(A/2) / BS]	0.43	
	Acceptable minimum capping depth for a slightly rounded crest (m)	P	nominated	0.30	G/H
	Total mound height for a perfectly peaked mound (m)	H_1	(D_c + P_1 + F) + C	1.28	
	Total mound height with minimum capping depth (m)	H	(D_c + P + F) + C	1.15	
15	Upslope mound width, from geometry (m)	I_g	geometric calculation	1.97	
16	Upslope mound width, from hydraulics (m)	I_h	If NS=0, I_h=(LLR/BLR-A)/2, IF NS>0, calc. I from geometry	n/a	
17	Upslope mound width - larger of I_g and I_h (m)	I		1.97	
	Endslope mound width, from geometry (m)	K	BS × (D_c + F + G)	2.85	
18	Downslope mound width, from geometry (m)	J_g		6.29	
19	Minimum downslope mound width, from hydraulics (m)	J_h	If NS=0, J_h=I_h If NS>0, J_h=(LLR / BLR) - A	5.40	
20	Downslope mound width - larger of J_g and $J_{h\,(m)}$	J		6.29	
	Mound Dimensions (all in m)				**Key**
	ABSORPTION BED:				
	Absorption bed width:	A		1.4	A
	Absorption bed length:	B		23.0	B
	Absorption bed thickness:	F		0.25	F
	MOUND:				
	Basal width:	W	I + A + J	9.6	
	Basal length:	L	B + (2 × K)	27.9	L
	Total height:	H	D_c + P + F	1.2	
	Upslope mound width:	I		2.0	I
	Downslope mound width:	J		6.3	J
	Endslope mound width:	K		2.9	K

Linear Loading Rates

Soil Texture	Soil Structure	Linear Loading Rate (L/m/day)								
		slope < 5%			Slope 5 - 10%			slope 10 - 15%		
		Depth to limiting layer			Depth to limiting layer			Depth to limiting layer		
		0.2 - 0.3	0.31 - 0.6	> 0.61	0.2 - 0.3	0.3 - 0.6	> 0.6	0.2 - 0.3	0.3 - 0.6	> 0.6
Gravel, sand, loamy sand, clayey sand	Massive	62	78	93	78	93	109	93	109	124
Sandy loam, fine sandy loam	Massive	47	54	62	56	64	71	78	93	109
	Weakly to moderately structured	54	70	85	62	78	93	78	93	109
Loam, loam fine sandy	Massive	31	36	40	37	42	47	42	50	57
	Weakly structured	47	54	62	51	59	67	56	64	71
	Highly to moderately structured	51	59	67	56	64	71	60	68	76
Clay loam, sandy clay loam, fine sandy clay loam, silty loam	Massive	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Weakly structured	31	39	47	34	42	50	37	45	53
	Highly to moderately structured	37	45	53	42	47	51	47	54	62
Sandy clay, silty clay, clay	Massive	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Weakly structured	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Highly to moderately structured	31	39	47	34	42	50	37	45	53

Cross Section View





Plan View

Appendix E

Hazard Class Confirmation

Greater Taree Council DAF (2012) Hazard Class Confirmation Checklist

Project No. : 1308	Final Hazard Class
Property: Lot 2 DP1120671 Alpine Drive, Tinonee	High

Notes:
* To obtain the 'Final Hazard Class', use the hazard classification table below. Simply select the appropriate hazard rating for each environmental factor and enter it in the corresponding 'Hazard Class' column.
* Input cells are marked in Green, while outputs cells are marked in Red.

Environmental Factor	Parameter	Hazard Rating	Definition	Hazard Class
Slope	0 - 10%	Low	No influence	medium
	10 - 15%	medium	Limited opportunity for standard design	
	15-30%	Shigh	Limited options for sustainable on-site sewage management	
	>30%	very high	Very Limited options for sustainable on-site sewage management	
Soil	Profile Depth	Low	Greater than 2 m depth	Medium
		Medium	1 - 2 m profile depth	
		High	Less than 1 m profile depth	
	Texture, structure, indicative permeability and drainage	Low	Pedal loam to clay loam soils with mid-range permeability and moderate to free drainage	Low
		Medium	Generally imperfectly drained, weakly structured clay loams and light clays or deep, rapidly drained sands (e.g. sand hills)	
		High	Generally shallow structureless clays and sands in either very rapidly or very poorly drained landscapes	
	Nutrient retention, sodicity and organic content	Low	Generally soils with high CEC and/or phosphorus sorption capacity, no sodicity potential and moderate organic content in topsoil	Low
		Medium	Generally soils with moderate CEC, phosphorus sorption capacity, no sodicity potential and good organic content in topsoil	
		High	Generally soils with low CEC, phosphorus sorption capacity, sodicity potential and/or limited organic content	
Climate	0 - 1 months SMS	Low	Evapotranspiration is a significant output for much of the year and/or soil storage is substantial	high
	2 - 3 months SMS	medium	Evapotranspiration provides legitimate output for applied effluent for 75% of the year and soil storage is sufficient to buffer short term wet periods	
	4+ months SMS	high	Soil moisture typically exceeds field capacity for half of the average year resulting in either significant deep drainage or surface surcharging	
Proximity	Within 40 m Buffer around intermittent watercourses and drainage channels	Yes	Increased potential for effluent run off or subsurface seepage to sensitive environments	No
	Outside of 40 m Buffer around intermittent watercourses and drainage channels	No	No influence	
	Within 100 m Buffer around permanent watercourses and drainage channels	Yes	Increased potential for effluent run off or subsurface seepage to sensitive environments	No
	Outside100 m Buffer around permanent watercourses and drainage channels	No	No influence	
	LAA point of application below 5% AEP flood level	Yes	Site specific design required, however, careful design and construction will often manage the hazard adequately	No
	LAA point of application above 5% AEP flood level	No	No influence	
Receiving Env	Within 100 m buffer around SEPP 14 wetlands	Yes	Increased potential for effluent run off or subsurface seepage to sensitive environments	No
	Outside of 100 m buffer around SEPP 14 wetlands	No	No influence	
	Within 500 m buffer around the aquaculture leases dataset	Yes	Proximity to aquaculture leases increases the potential for impacts	No
	Outside of 500 m buffer around the aquaculture leases dataset	No	No influence	

Soil Hazard Class Determination

Hazard Type	Hazard Class	Hazard Rating	Weighting	Final Soil Hazard Rating
Profile Depth	Medium	2	1.5	1.5
Hydraulic	Low	1	1	
Pollution	Low	1	0.5	

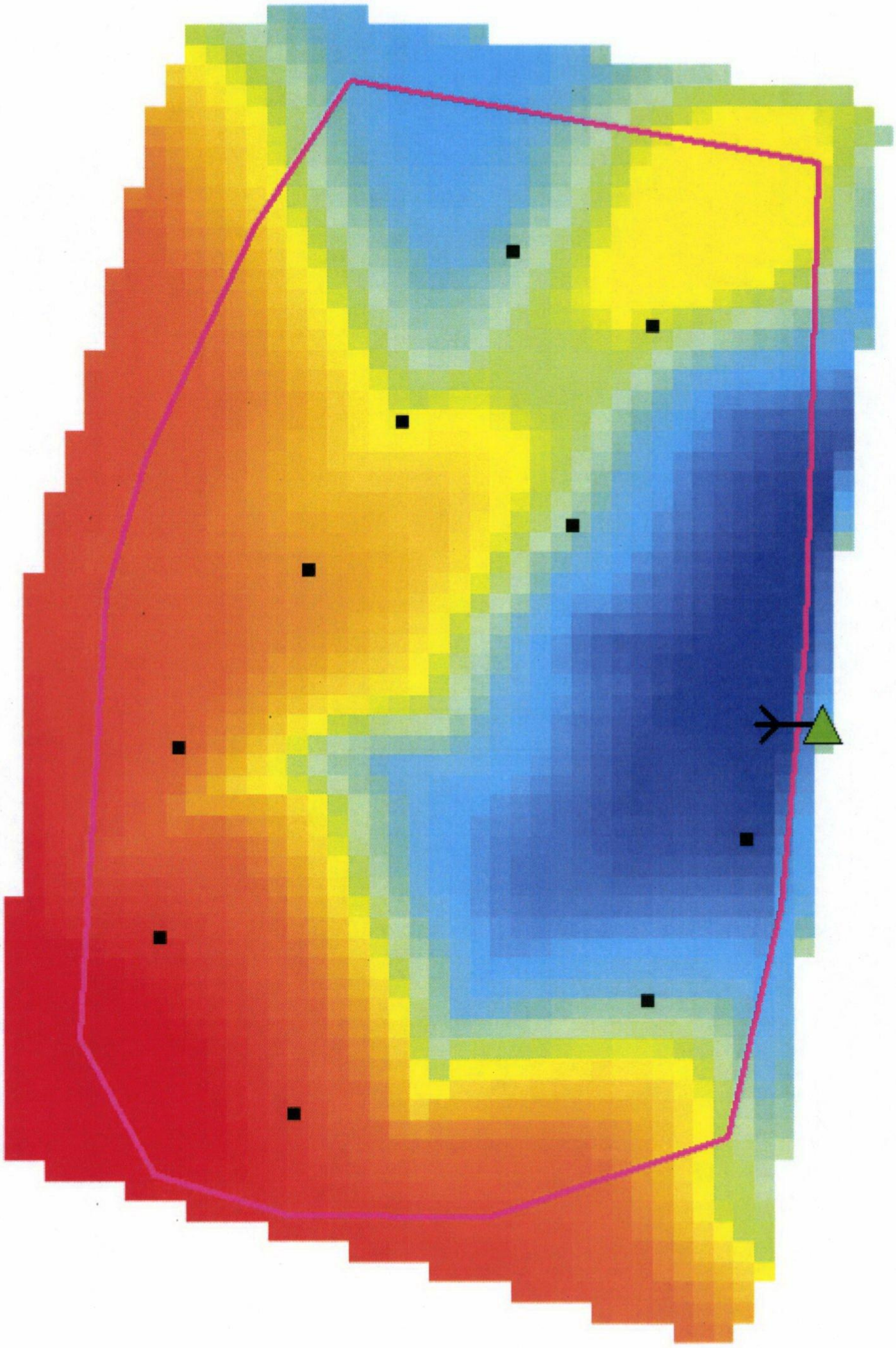
Appendix F

DSM Inputs & Results

HYDRAULIC AREAL LOADINGS TABLE	Proposed	Existing
Size of LAA (m2)	780 / 1280	300
Number of Lots within the Development	2	
Total (combined) LAA of Site (m2)	8820.00	
Mean Surface Surcharge for Site (mm/day) (L/m2/day)	0.000	
Mean Deep Drainage for Site (mm/day) (L/m2/day)	0.29	

TOTAL ANNUAL LOADS - Site	RECEIVING NODE	CONVERSION	UNITS	CONVERSION	UNITS
Mean Annual Surface Runoff (m3) =	0.000	0.000	L/yr	-	ML/yr
Mean Annual Surface N (g) =	0.000	0.000	kg/yr		
Mean Annual Surface P (g) =	0.000	0.000	kg/yr		
Mean Annual Surface V (MPN) =	0.000	0.000	cfu/100ml		
Mean Annual Deep Drainage (m3) =	947.63	947,630.00	L/yr	0.95	ML/yr
Mean Annual Deep Drainage N (g) =	4.05	0.004	kg/year		
Mean Annual Deep Drainage P (g) =	101.56	0.102	kg/year		
Mean Annual Deep Drainage V (MPN) =	3,562.36	0.000	cfu/100ml		

POLLUTANT CALCULATIONS (Fletcher, 2004)	BACKGROUND -Site
Mean Annual Rainfall (mm)	1,176
Land Use Type	Rural
Impervious Percentage (%)	0
Background N (kg/ha/yr)	0.25
Background P (kg/ha/yr)	3.71
Site Area (ha)	17.5
Total Background N (kg/yr)	4.35
Total Background P (kg/yr)	64.89



DSM Model Layout Screenshot (black points are the site nodes or LAAs, the pink polygon is the management unit, green triangle is the receiving node and the black directional line is the link between the subdivision and the receiving environment).